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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : A61G 7/00	A1	(11) International Publication Number: WO 95/21599
		(43) International Publication Date: 17 August 1995 (17.08.95)

(21) International Application Number: PCT/US95/01505

(22) International Filing Date: 13 February 1995 (13.02.95)

(30) Priority Data:
08/196,847 15 February 1994 (15.02.94) US

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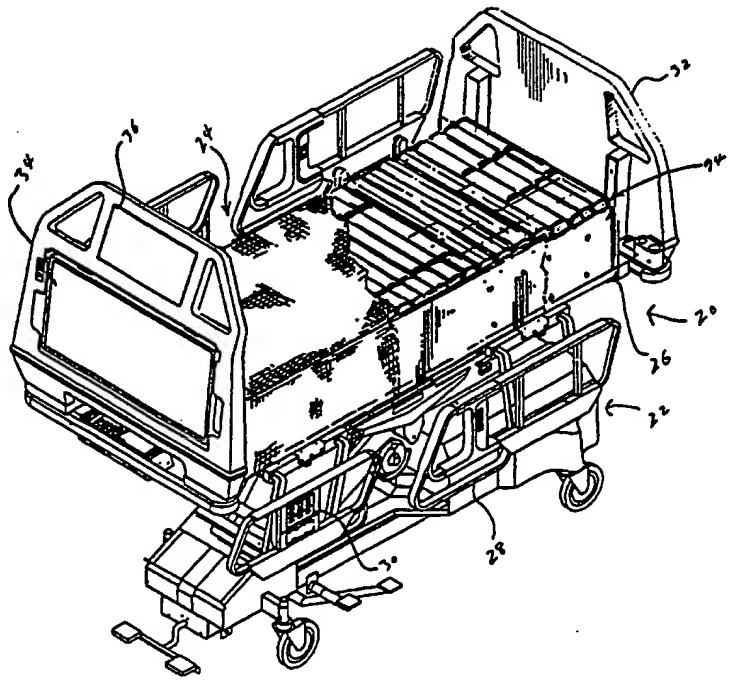
(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: METHOD AND APPARATUS FOR SUPPORTING AND FOR SUPPLYING THERAPY TO A PATIENT

(57) Abstract

An apparatus (20) is provided which supports a patient on an inflatable structure (24). The inflatable structure (24) preferably has two components: a lower inflatable layer (74) which is selectively operable to provide basic support for the patient and which includes a plurality of laterally offset zones (78, 80, 82) which may be independently inflatable to control rotation of the patient. Further, a second inflatable layer (92) includes a plurality of zones (160, 162, 164, 166, 168, 170) for establishing optimal patient interface pressures and patient comfort levels, and may also include sufficiently independent inner chambers to facilitate the providing of specific therapies such as alteration of primary pressure contact areas, or percussion or vibration of the patient through inner cell inflation.



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METHOD AND APPARATUS FOR SUPPORTING AND FOR SUPPLYING THERAPY TO A PATIENT

BACKGROUND OF THE INVENTION

The present invention relates generally to inflatable support surface beds, and more specifically relates to inflatable support surface beds providing low air loss patient support, or providing other therapies, to a patient supported thereon.

Numerous types of inflatable patient support surfaces have been proposed to support patients. One generic configuration of such a support system in use today includes a plurality of transverse air bags extending across the width of the bed support surface. A plurality of such bags are arranged in parallel to form either a part, or the entirety, of the patient support surface. As is well known relative to such beds, a blower supplies air through a manifolding system to each of the air bags. This manifolding system includes a controller, such as a microprocessor controller, which operates a plurality of valves to control the air flow to sets of one or more of the air bags forming "zones" of the bed.

One therapy offered by such beds is low air loss patient support. In this configuration, at least some of the bags will include either small apertures, or will be formed in whole or in part of air permeable fabric, to provide a flow of air to dry the bag and/or cover surface to thereby reduce the risk to the patient of bed sores.

Another therapy offered in conventional beds is turning, or lateral rotation, of the patient. Dramatically different systems exist in the prior art for turning a patient with transverse air bags. For example, one conventional system deflates alternate single-celled air bags along the length of the patient to allow the patient to drop into recesses or cutouts in the other set of air bags,

which remain fully inflated. Another, different, system utilizes the deflation of cells in multi-celled cushions all along the length of one side of the patient to lower that side of the patient, and the corresponding inflation of cells all along the length of the other side of the patient to simultaneously raise that side of the patient. The different approaches of each of the systems may present disadvantages in certain situations, however. Both systems can offer less than optimal patient support over a long term in some applications.

Other therapies which are found in conventional acute care beds include pulsation and percussion. Pulsation, or alternating of contact (support) points, has long been utilized in an attempt to reduce patient tissue damage, such as decubitus ulcers. Examples of such alternating pressure surfaces include U.S. Patent No. 2,998,817 to Armstrong, issued September 5, 1961; and EPO Application No. 0-168-215 to Evans, published January 15, 1986. Percussion therapy consists of a sharp impact of pressure, preferably only in the chest area of the patient, to assist in maintaining portions of the patients' body, typically the lungs, clear of pooled fluid. Conventional apparatus utilize a quick inflation of a cell beneath the patient to provide the impact. The frequency of the percussive therapy may be increased to provide vibratory therapy.

Notwithstanding what therapies are offered, a primary concern with an inflatable bed or support surface is patient comfort. Because patients may remain on these types of beds for extended periods of time, the ability to provide an optimally comfortable support surface is an important objective of any inflatable support assembly. This objective remains even when therapies such as those discussed above are offered.

Another objective of an inflatable support assembly will be to provide a system to maintain a patient properly positioned on the bed during normal situations. This may be of particular importance during rotational therapy. The prior art has only achieved this objective with a limited degree of success.

Accordingly, the present invention provides a new method and apparatus for supporting the patient on an inflatable support surface, and for providing optimal comfort and patient positioning, while having the further capacity, as desired, to provide a range of therapies such as, for example, low air loss support, rotation, varying support pressure ("relaxation"), percussion or vibration to the patient.

SUMMARY OF THE INVENTION

The present invention provides a bed having an improved support surface assembly, and provides a bed suitable for providing a variety of therapies to a patient through the improved support surface assembly. The support surface in accordance with the present invention preferably includes at least two independently inflatable layers. In one preferred embodiment of the support surface assembly, a lower layer of the support surface assembly includes first and second longitudinal cushion sets coupled to a support assembly, such as a support plate. The first longitudinal cushion set includes a plurality of generally parallel cells; which, in a particularly preferred embodiment, are formed as separate and distinct cushions. This first set of longitudinal cushions extends a portion of the longitudinal length of the support assembly; i.e., a portion of the longitudinal length or height of the patient. The second longitudinal

cushion set is constructed similarly to the first longitudinal cushion set, but extends at a longitudinally offset portion f the length f the support assembly (or of the patient's length). One particularly preferred mbodiment of the invention includes three such longitudinal cushion sets, sequentially longitudinally disposed beneath the patient. These longitudinal cushion sets provide control over the patient's positioning in the bed, and are independently inflatable in preferably at least three longitudinally - divided (i.e., laterally offset) groups, to facilitate rotation of the patient to the left and right through selective inflation and deflation of the longitudinally - divided groups.

In this preferred embodiment, disposed between the longitudinal cushion sets and the patient is an inflatable support layer. Preferably, this inflatable support layer is a discrete and separate assembly from the cells forming the lower layer of the support surface assembly. This inflatable support layer is preferably constructed to provide air leakage, or to otherwise facilitate the flow of air through the layer in at least selected locations. Further, this inflatable support layer preferably includes a predetermined number of independently controllable zones distributed around the patient's body whereby the pressure in individual zones can be adjusted to provide optimal patient comfort. Further, in a particularly preferred embodiment, one or more sections of the inflatable layer also include inflatable, relatively laterally external, enclosures which are maintained at a relatively increased pressure relative to a central enclosure to facilitate the cradling of the patient proximate the central portion of the bed. In addition to stabilizing the patient's position, these cradling sections, at a higher pressure, also serve to stabilize the patient during rotation. Again in one particularly embodiment, the inflatable support layer also includes

provisions under a selected portion f the patient's body, for example the chest area, for providing percussive or vibratory therapy to the patient to facilitate the loosening and m vement of fluids from the patient's lungs.

An exemplary bed including a support surface as described above is preferably controlled through use of a conventional microprocessor system to regulate a plurality of proportional valves which modulate airflow between a blower assembly and the air cushions. Appropriate pressure feedback mechanisms and circuitry are provided to facilitate the microprocessor's monitoring of the pressure in the inflatable air cells relative to predetermined or desired levels, and appropriate regulation of the airflow to the cells.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 depicts an exemplary bed constructed in accordance with the present invention.

FIG. 2 depicts a support frame assembly of the bed of FIG. 1, depicted in an exploded view.

FIG. 3 depicts the support surface assembly of the bed of FIG. 1, also depicted in an exploded view.

FIG. 4 is a schematic representation of the interconnection of air inlets and outlets in the support plate assembly of the bed of FIG. 1.

FIG. 5 schematically depicts the vertical construction of the support plate of FIG. 4.

FIG. 6 represents an exemplary illustration of the construction of the support plate assembly of FIG. 4, illustrated in vertical section.

FIG. 7 schematically depicts the air manifold and a valve box of the support frame assembly of FIG. 2.

FIGS. 8A-D depicts a head section working cushion of the support surface assembly of FIG. 3, illustrated with internal structure depicted in phantom lines; depicted in FIG. 8A from a top view; depicted in FIG. 8B from a side view; depicted in FIG. 8C from a bottom view; and depicted in FIG. 8D from an end view.

FIGS. 9A-D depicts a seat section working cushion of the support surface assembly of FIG. 3 illustrated with internal structure depicted in phantom lines; depicted in FIG. 9A from a top view; depicted in FIG. 9B from a side view; depicted in FIG. 9C from a bottom view; depicted in FIG. 9D from an end view.

FIGS. 10A-C depicts a leg section working cushion of the support surface assembly of FIG. 3 illustrated with internal structure depicted in phantom lines; depicted in FIG. 10A from a top view; depicted in FIG. 10B from a side view; and depicted in FIG. 10C from a bottom view.

FIG. 11 depicts the overlay assembly f the support surface assembly of FIG. 3, illustrated from a top view.

FIGS. 12A-D depict the head section of the overlay assembly of FIG. 11, illustrated with internal structure depicted in phantom lines; depicted in FIG. 12A from a top view; depicted in FIG. 12B from a side view; depicted in FIG. 12C from a bottom view; and depicted in FIG. 12D from an end view.

FIGS. 13A-C depict the chest section of the overlay assembly of FIG. 11, depicted in FIG. 13A from a top view and depicting internal cells; and depicted in FIGS. 13B and C from opposing side views.

FIGS. 14A-D depict a section of the overlay assembly of FIG. 11 as is used with the seat or thigh sections, illustrated with internal structure depicted in phantom lines; depicted in FIG. 14A from a top view; depicted in FIG. 14B from a side view; depicted in FIG. 14C from a bottom view; and depicted in FIG. 14D from an end view.

FIGS. 15A-D depict a cushion as is used in combination to form the foot section of the overlay assembly of FIG. 11; depicted with internal structure depicted in phantom lines; depicted in FIG. 15A from a top view; depicted in FIG. 15B from a side view; depicted in FIG. 15C from a bottom view; and depicted in FIG. 15D from an end view.

FIG. 16 schematically depicts an exemplary electrical control circuit useful with the bed of FIG. 1.

FIG. 17 depicts an exemplary flowchart for the patient pressure baseline setup routine for a bed in accordance with the present invention.

FIG. 18 depicts an exemplary flowchart for the setup of blower pressure for a bed in accordance with the present invention.

FIGS. 19A-F depict an exemplary flowchart for the implementation of rotation therapy in a bed in accordance with the present invention.

FIG. 20 depicts an exemplary flowchart for implementation of pressure relief, or "relaxation", therapy for a bed in accordance with the present invention.

FIG. 21 depicts an exemplary flowchart for implementation of percussion therapy for a bed in accordance with the present invention.

FIG. 22 depicts an exemplary flowchart for implementation of vibration therapy for a bed in accordance with the present invention.

FIG. 23 depicts an exemplary flowchart for implementation f combination percussion and vibration therapy for a bed in accordance with the present invention.

FIG. 24 depicts a portion of the insertion of working cushions on a portion of support frame assembly of support surface assembly of FIG. 3.

FIG. 25 depicts an exemplary connector suitable for use in connecting tubing or other members to supply air between the support plate assembly and the overlay assembly of FIG. 11.

FIGS. 26A-B schematically depict the zones of the overlay assembly of FIG. 11, illustrating the independently controllable portions thereof.

FIGS. 27A-B schematically depict the zones of the working cushions of FIG. 3, and the independently adjustable portions thereof.

FIGS. 28A-B depict an exemplary seat dump valve useful with the present invention.

FIG. 29 depicts a front view of an exemplary control panel useful with the bed of FIG. 1.

FIG. 30 depicts an exemplary assembly as may be used to supply air to cells in the overlay assembly of FIG. 11, and in particular to the foot section thereof.

FIG. 31 depicts an exemplary embodiment of air box assembly of FIGS. 2 and 7, depicted in an exploded view to show internal structure.

FIG. 32 depicts a clip-retained connector as may be utilized to establish fluid communication between the outermost cushions and the support surface of FIG. 3.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings in more detail, and particularly to FIG. 1, therein is depicted an exemplary bed 20 constructed in accordance with the present invention. Bed 20 includes a support frame assembly, indicated generally at 22, and a support surface assembly, indicated generally at 24.

Support frame assembly 22 preferably includes a conventional, multi-featured hospital bed frame 26, such as the Century Critical Care Frame®, manufactured by Hill-Rom Co., a subsidiary of Hillenbrand Industries, of Batesville, Indiana. Bed frame 26 includes conventional bed position functions and controls to change the bed height, articulation, etc.; and also includes conventional mechanisms, such as siderails 28 for patient safety. Coupled to bed frame 26 is a headboard assembly 32 and a footboard assembly 34. Footboard assembly 34 preferably includes a control panel 36 which includes an LCD screen and a plurality of membrane switches. Control panel 36 controls air support and therapy functions of bed 20, as will be described in more detail later herein.

Referring also to FIG. 2, therein is depicted support frame assembly 22 in an exploded view. Support frame assembly 22 includes a blower and air filter assembly 40 operably coupled to frame 26. Blower and air filter assembly 40 will be selected to provide an utput based upon the desired pressure range desired for inflation of the cells in support surface assembly 24 and the determined leakage rates from such cells.

An electrical box 41 and battery assembly 42 are also provided on frame 26. Battery assembly 42 will provide power for the operation of bed 22 during transfer or other interruptions of power. Although bed 20 is designed to operate from conventional AC power (which is converted to DC power), battery assembly 42 includes batteries which provide a supply of DC power to operate at least basic patient support functions during periods of AC power interruption. Battery assembly 42 is of a conventional design and is operably coupled to the electrical control system of bed 20 in a conventional manner.

Blower 40 is operably coupled through an appropriate conduit assembly 44a, 44b, 44c, 44d, and 44e to an air box 46. Conduit assembly 44 is partially formed of rigid channel conduit elements 44b and 44d, and includes appropriate flexible elements: flexible conduit 44a coupled between blower 40 and channel conduit 44b; flexible conduit 44c coupled between channel conduit 44b and rising conduit 44d; and flexible conduit 44e coupled between rising conduit 44d and air box 46.

Referring now also to FIGS. 7 and 31, air box 46 is operably coupled to a valv manifold 48. Each f a plurality f valves 50 (for clarity, nly one valve is illustrated) engages an outlet 52a-j on valve manifold 48 to selectively supply air to specific air channels throughout support surface assembly 24, as will be described in more detail later herein. A hose assembly 54 couples to each valve 50 to provide fluid communication between the valve outlet 52 and support surface assembly 24.

Air box 46 includes a pair of solenoid valves 480, 481 which are in at least selective fluid communication with air from blower 40 through conduit assembly 44, such as through a T-coupling 482 to which conduit 44e is coupled. Solenoid valves 480, 481 provide control of air to outlet 484 to facilitate percussion and vibration therapy, as will be described later herein. Outlet 484 is depicted as having three outlet ports 483 which will be coupled by appropriate tubing to inlet ports 440 (in FIG. 4) on the bottom side of support plate assembly 64 in parallel. Alternatively, more or fewer ports may be provided to facilitate the flow of air through conduits to selected chambers in support surface assembly 24. First air control valve 480 is preferably energized to a normally closed position to block the passage of air to outlet 484. Selective rapid actuation opening valve 480, while valve 481 is in a closed condition will provide a pulse of air to outlet 484 (and thereby to selected chambers, in support surface assembly 24). Subsequent closing of valve 480 while opening valve 481 will allow air to be expelled from outlet 484 through valve 481.

Briefly, as is well-known in the art, each valve 50 is a proportional valve which is individually controlled, through appropriate feedback and control circuitry, by a microprocessor-based controller. As a portion f the feedback control, each valve 50 has a pressure feedback tube 56 (a-j) operably coupled between the outlet side of an individual valve 50 and a pressure sensor on a power control circuit board assembly (not illustrated) associated with the valve 50. Additionally, a pressure feedback tube 56k is utilized to monitor pressure in manifold 48.

An exemplary structure and method of operation of air control valves is described generally in U.S. patent 5,251,349, issued October 12, 1993 to Thomas et al.; the disclosure of which is hereby incorporated herein by reference for all purposes. It should be understood, however, that any of a number of conventionally known valve configurations may be utilized with the present invention. Alternatively, each air control valve may be as disclosed in U.S. patent application 08/088,541, entitled "Proportional Control Valve for Patient Support System," filed July 7, 1993 in the names of Ryszard S. Ozarowski et al. and assigned to the owner of the present invention; the disclosure of which is hereby incorporated herein by reference for all purposes.

A plurality of air channel monitoring tubes 58 are also each cooperatively arranged, at a first end with a valve 50 outlet, and at a second end to an access plate 60. Each monitoring tube 58 will be closed proximate access plate 60 by a conventional releasable sealing mechanism (not illustrated). Air channel monitoring tubes 58 allow the external monitoring and/or variation of pressures within individual air channels in support plate assembly 64.

As is familiar to those skilled in the art, a plurality f shroud panel assemblies 62, 64, and 66 attach to bed frame 26 to protect components of support frame assembly 22 and to provide aesthetic appeal f the assembly.

Referring now primarily to FIGS. 3 and 24, therein is depicted support surface assembly 24 in greater detail. Coupled to bed frame 26 (only a portion of which is depicted for clarity) is a support plate assembly, indicated generally at 64. Support plate assembly 64 provides a solid surface upon which is supported a first, lower, inflatable level 74 and a second, upper, inflatable level 92.th As will be described in more detail later herein, lower inflatable layer 74 and upper inflatable layer 92 are preferably each divided into a plurality of zones, separately coupled to individual proportional air control valves 50.

Support plate assembly 64 preferably includes a plurality of four individual sections, 66, 68, 70, and 72, operably coupled to bed frame 26 to extend generally the full length between headboard assembly 32 and footboard assembly 34 (see FIG. 1). First support frame section 66 includes a central radiolucent panel 98. As is known to the art, radiolucent panel 98 is preferably formed of a composite phenolic resin, such as is known by the trade name Recitin; and facilitates the taking of X-rays of a patient without removing the patient from the bed 20. A flexible strip 74a-c is secured between adjacent sections 66, 68, 70, and 72 of support plate assembly 64 to cover spaces between the sections which may change in size as bed frame 26 is articulated, thereby tilting sections 66, 68, 70, and 72 relative to one another.

Support plate assembly 64 includes a plurality of releasable air connector members which facilitate releasable connections between enclosures in lower inflatable layer 74 and upper inflatable level 92. In a preferred implementation, a first, pull-release "quick disconnect" form of connector, indicated generally at 100, is utilized to selectively engage complimentary connectors on the air cushions of lower inflatable level 74; and a second manual-release form of connector, indicated generally at 102, is utilized to selectively engage complimentary connectors and tubing coupled to upper inflatable level 96 to establish fluid communication therewith. Quick disconnect connector members 100a (schematically represented by large circles in FIG. 4, and as exemplary identified at 504, 506, and 508 in FIG. 4), are configured to engage complimentary connector members 100b on the cushions of lower inflatable level 74, and are generally described in reference to FIGS. 2, 3, 5, and 6 of U.S. Patent 5,251,349 to Thomas, et al., previously incorporated by reference. Connector members as depicted in U.S. Patent 5,251,349 include a flange which rests against the upper surface of the support plate and an extension which extends through the support plate and to which a threaded coupling is attached to secure the connector member to the support plate. As an alternative, and preferred, construction, the flange of the connector may include a plurality of apertures to facilitate the securing of the connector member to the support plate through screws rather than through the described threaded coupling. An exemplary manual release connector 102 (schematically represented by smaller circles in FIG. 4, and as exemplary identified at 502), as is utilized to couple the tubing extending to upper inflatable level 94, is described herein in reference to FIGS. 25A-B.

A limited number of clip-retained couplings 103 are utilized to establish fluid communication between support plate assembly 64 and the laterally outerm st cushions of l wer inflatable layer 74. These couplings are represented by double concentric circles in FIG. 4, and are depicted and discussed herein in relation to FIG. 32.

Referring now also to FIGS. 4-6, therein is depicted, in FIG. 4, support plate assembly 64 in a schematic view, and from side views in FIGS. 5 and 6. Support plate assembly 64 is preferably a multi-level composite assembly which defines a plurality of air passageways; and which acts, therefore, as a manifold for distributing air from proportional valves 50 to individual zones in lower inflatable layer 74 and upper inflatable layer 92.

Support plate assembly 64 is preferably constructed of a plurality of PVC layers 160, 162, 164 adhesively coupled together as a central core, with a layer of aluminum plate 166, 168 at the top and bottom, respectively; and with a layer of an external plastic coating 170 extending around the entire assembly. As can best be seen in FIG. 5, support plate assembly 64 is constructed with an exterior recess 174 at the lower surface so that support plate assembly 64 will fit partially within the confines of bed frame 26. To form exterior recess 174, support frame assembly 64 preferably includes only two PVC layers 160, 162, proximate the exterior edge, and includes only the upper aluminum layer 166 proximate the exterior edge.

In one particularly preferred embodiment, each PVC layer 160, 162, 164 will be formed of a layer of expanded PVC foam having a thickness of approximately ten millimeters (or .39

inch). As depicted in FIG. 6, each PVC layer will have paths (indicated exemplary at 176) formed therein to provide the desired flow channels, as schematically depicted in FIG. 4. The PVC layers 160, 162, 164 are bonded together, and to aluminum plates 166, 168, with an adhesive, such as a methacrylate adhesive. Each aluminum plate is preferably approximately .067 inch thick. Plastic coating layer 170 may be of any suitable type, such as, for example an ABS/PVC blend, such as that marketed under the name Kydex T, by the Kleerdex Company of Aiken, South Carolina.

Referring primarily to FIG. 4, each section 66, 68, 70, and 72 of support plate assembly 64 is preferably constructed to define two or three levels of flow paths (see FIG. 6), defining ten distinct flow channels; indicated generally at 110, 112, 114, 116, 118, 120, 122, 124, 126, 128. Each of the above flow channels is operatively coupled to an air inlet 110a, 112a, 114a, 116a, 118a, 120a, 122a, 124a, 126a, 128a, respectively on the lower side of section 66. Each such air inlet is coupled through an appropriate conduit 52 to a respective air control valve 50. Each flow channel 110, 112, 114, 116, 118, 120, 122, 124, 126, 128 then extends through support plate assembly 64 to operatively couple to one or more quick disconnect connector members 100a, manual release connector member 102a, or clip-retained coupling 103 to provide fluid communication between a respective air control valve 50 and one or more cushions of first inflatable levels or zones of second inflatable level 96. In many cases, an air channel 110, 112, 114, 116, 118, 120, 122, 124, 126, 128 extends across one section 66, 68, 70, or 72 of support frame assembly 64 to another such section. For example, air passageway 110 extends at 130 between first section 66 and second section 68 of support plate assembly 64. In such cases, a

conventional coupling will be secured to extend from the lower surface of each section, and a flexible tube or bellows (not illustrated) will be connected to the couplings to connect the air channel between such sections.

As can also be seen in FIG. 3, bed 20 includes first, lower inflatable level, indicated generally at 74, supported upon support plate assembly 64. First inflatable level 74 is preferably formed of a plurality of generally longitudinally extending cells. In one preferred embodiment, these longitudinally extending cells are formed of individual longitudinally extending cushions, indicated generally at 76, arranged generally in parallel in three longitudinally - extending, sequentially arranged, groups, 78, 80 and 82.

As can be seen in FIGS. 1 and 3, each group 78, 80, 82 of longitudinal cushions 76 includes eight generally parallel, longitudinally extending cushions. First cushion group 78 will extend primarily under the head and upper torso of the patient. The cushions of first cushion group 78 are coupled together at an upper end by a first fabric panel 83, which couples to the end of each individual cushion, preferably by a pair of conventional snap fittings. First fabric panel thereby serves to maintain the lateral spacing of the cushions of first cushion group 78 at the upper end. All snap fittings are preferably "Pull-The-Dot" snap fittings, such as Model Nos. 92-18100/92-18201, or 92-18302/93-10412 as manufactured by Scovill Fasteners, Inc. of Clarksville, Georgia.

The second cushion group 80 will extend primarily under the seat and upper thigh portion f the patient. Each cushion of second cushion group 80 is coupled at an upper end to a respective cushion f first cushion group 78. A transversely-extending fabric panel 84 extends between the cushions of first cushion group 78 and second cushion group 80 and includes apertures therein to facilitate the opening of the cushions through panel 84. Similarly, the cushions of third cushion group 82, which will extend generally under the legs and feet of the patient, are again coupled together at an upper end, by snaps, to the cushions of second group 80 through apertures in a fabric panel 86; and are coupled at the lower end to a fabric panel 90. Each transverse fabric panel 83, 84, 86, and 90 preferably includes at least one tab having a plurality of snap fittings therein to facilitate attachment to side panels 96.

Each cushion 76 is preferably constructed of twill woven nylon coated on the interior surface with a sealing material, such as urethane, so as to make each cushion generally air tight. The cushions of each group will preferably be approximately 7.5 inches high, but will vary in length. In one preferred embodiment, the central six cushions of lower level 74 are each preferably approximately 4 inches wide, while the outermost "bolster" cushions are each approximately 2.5 inches wide. Other than as to material, the "working" cushions of each group 78, 80, and 82 will preferably be constructed somewhat differently from the cushions of other groups. Each working cushion may include at least one connector member which will engage a complimentary connector member on support surface assembly. In the depicted embodiment, the six most central cushions of each cushion group include a quick disconnect connector 100b by which the cushions are coupled to a complimentary connector 100a secured to support surface

64. The two outermost cushions of each cushion group each include clip-retained connectors (103b in FIG. 32) by which fluid communication is established with receptacles 103a m unted on support surface 64. Essentially identical side panels 96 will extend the longitudinal length of lower inflatable level 74, and will preferably couple to each outer cushion and to each transverse panel 80, 84, 86, 90 by a plurality of snaps. Each side panel 96 will then also couple, again by a plurality of snaps to an adjacent portion of support frame assembly 22. Each side panel 96 also includes a closeable slot to facilitate the placement of an X-ray film magazine between the cushions of lower inflatable layer 74 and upper inflatable layer 92, if so desired. Such slot may be closeable through use of a zipper, snaps, or a hook and eye fabric fastener.

Referring now to FIGS. 8A-D, therein is depicted an exemplary head section cushion 180 of group 78. In a particularly preferred embodiment, each head section cushion 180 is approximately 32 inches long. Each of the central six head section cushions 180 preferably includes two distinct, independently controllable chambers 182, 184. First chamber 182 is that portion which will lie under, and which will support, the patient's head. First chamber 182 includes a coupling 186 to cooperatively engage a length of tubing extending to a manual release connector 102 coupled to support surface assembly 64 (for example, items 502, coupled to air channel 116 in FIG. 4), by which chamber 182 may be supplied with air.

Second chamber 184 will lie under the upper torso or shoulders of the patient. Cushion 180 includes a connector 100b to provide fluid communication between chamber 184 and a complementary connector member 100a on support plate assembly 64. (For example, items 504,

coupled to air channel 120, for the center working cushion zone, in FIG. 4.) Cushion 180 will also preferably include a pair f baffles, 190, 192, respectively, one in each chamber 182, 184 to assist in maintaining the generally rectangular shape of cushion 180 during inflation. The outer two bolster head cushions will preferably each define only a single chamber.

Referring now to FIGS. 9A-C, therein is depicted an exemplary seat working cushion 194 of group 80. Seat section working cushion 194 is preferably approximately 22.8 inches long. Each of the central six seat section cushions 194 includes a single quick disconnect connector member 100b to facilitate attachment of cushion 194 to support plate assembly 64 (see item 506 for the center working cushion zone, coupled to air channel 120, in FIG. 4). Seat section cushion 194 is a generally rectangular cushion which defines a single internal chamber. A notch, or relief, 198, however, is formed in lower surface 200 of cushion 194. When seat section cushion 194 is installed on support plate assembly 64, cushion 194 will extend across a central articulation point 202 of bed frame 26 (beneath flexible strip 74b in FIG. 3). Articulation of support plate assembly 64 at articulation point 202 will cause adjacent surfaces of support plate assembly 64 to move relative to one another. Notch 198 will accommodate such motion in support plate assembly 64 without placing unacceptable stress on cushion 194. Cushion 194 may also include one or more baffles 204 to facilitate the maintaining of the generally rectangular shape of cushion 204 during inflation.

Referring now to FIGS. 10A-D, therein is depicted leg and foot cushion 206 of cushion 82. Leg and foot cushion 206 will preferably again be approximately 22.8 inches in length.

Leg and foot cushion 206 is a generally rectangular cushion defining a single chamber, and (for the six central cushions) having a quick disconnect connector member 100b (which may couple, for example, to item 508, for the center working cushion zone, and to air channel 120, in FIG. 4).

As will be apparent from the preceding discussion, considered in view of the schematic of FIG. 4, the working cushions of first inflatable layer 74 are divided into four distinct zones. These zones are depicted, for example, in FIGS. 27A-B, as head zone 520 (depicted in darkened fill-in FIG. 27B) left zone 522 (depicted in darkened fill-in 27A); center zone 524 and right zone 526. Through control of appropriate valves as indicated in FIG. 4, and thereby through control of air into air channels 110, 116, 120, and 128, the degree of inflation in each of these four zones may be regulated by control panel 36.

Referring again to FIG. 3, as previously discussed, bed 20 also includes a second, upper, inflatable level, indicated generally at 92. Second inflatable level 92 is preferably a multi-celled overlay assembly 94 which extends essentially the full length of first (lower) inflatable level 74. Lower and upper inflatable levels 74 and 92 will be held within a cover 94. Cover 94 will preferably be formed of a moisture vapor permeable fabric, such as that marketed under the trade name Dermaflex by Consoltex Inc., of New York, New York.

Referring now to FIG. 11, therein is depicted an exemplary embodiment of multi-section overlay assembly 94, forming upper inflatable section 92. Overlay assembly 94 may be

constructed as a single unitary assembly. In a particularly preferred embodiment, however, overlay assembly 94 is formed f a plurality of, and most preferably f five, individual sections 148, 150, 152, 154, and 156; with section 156 formed f three distinct cushions 157a, 157b, and 157c. Adjacent sections 148, 150, 152, 154, and each cushion 157a-c of section 156 are preferably coupled together along transverse beads 158a, 158b, 158c, and 158d to form the complete assembly. The coupling of individual sections together is preferably through releasable coupling systems, such as the previously described snap fittings.

Referring now also to FIGS. 26A-B, overlay assembly 94 is utilized to provide primary control of patient comfort through control of interface pressures. Accordingly, overlay assembly 94 is preferably divided into six zones. A first, "head", zone, indicated generally at 160 (depicted in darkened fill in FIG. 26A), in first section 148 will support the patient's head.

A second "body" zone, indicated generally at 162, supports the patient's upper torso. Second zone 162 preferably includes a plurality of cells which may be [individually] controlled to provide percussion and vibration therapy to the patient, as described later herein. Preferably, second zone 162 will include at least four cells, each of which will preferably extend generally transversely under the patient's upper torso.

Overlay assembly 94 then includes three additional relatively central zones, a "seat" zone 164, a "thigh" zone 166, and a "foot" zone 168. An outer "bolster" or "cradle" zone 170 is intended to remain at relatively higher pressures than at least most of the above, relatively

central, zones of overlay assembly 94, and to thereby form a cradle for the patient. This bolster zone 170 may extend along both sides f each f the previ usly discussed zones. Preferably, the outer zone will extend on each side of all zones except second "upper torso" zone 162, which will extend the full width of overlay assembly 92. This cradle serves to maintain the patient in optimally central location on bed 20. The cradle zone will also serve to maintain the patient generally centered during lateral rotation to thereby prevent the patient from slipping significantly to one side and to prevent the patient from contacting the bed siderails. In one preferred implementation the cradle zone will be maintained at a pressure approximately 2 inches of water higher than the pressure in seat zone 164. During rotation, the cradle pressure may be increased, such as to approximately twice the pressure in the seat zone, or alternatively to approximately manifold pressure.

Overlay assembly 94 is preferably constructed in a low air loss configuration, wherein selected positions of the upper surface provide for the dispersal of air through the surface. Preferably, the seat and thigh sections 152 and 154 of overlay assembly 94 will be constructed in this manner. A variety of constructions are known to the art for providing such air dispersal and for providing so-called "low air loss" support. In a preferred embodiment, the bags are constructed in a generally airtight manner, and include a plurality of apertures, such as pinholes, placed therein to provide the desired airflow.

Referring now to FIGS. 12A-D, therein is depicted head section 148 of overlay assembly 94. Head section 148 includes three laterally disposed chambers 210, 212, 214. Central

chamber 212 is that section which will normally support the patient's head, and includes an air inlet 216 coupled to air channel 114 in support plate assembly 64 to facilitate independent control f the pressure in chamber 212. Air inlet 216 will preferably couple, for example, through a length of tubing to a manual release connector member 102b which will engage a complimentary connector member 102a, (identified as item 530 in FIG. 4). Outer head bolster chambers 210, 214 each include air inlets 218, 220 which couple in a similar manner to appropriate connectors 102a (see, for example, item 532 in FIG. 30), on support plate assembly 64 to couple to flow channel 124 provide lateral support for the patient's head. Each chamber 210, 212, 214 preferably includes a plurality of transversely extending internal baffles 222A, 222B, 222C in each chamber to maintain the shape of section 148 during inflation.

Referring now to FIGS. 13A-C, therein is depicted torso section 150 of overlay assembly 94. Torso section 150 includes a plurality, and preferably four, internal tubes or cells 151 extending generally across the width of torso section 150. All four tubes are housed within the larger inflatable envelope 155 of torso section 150. Each tube 151 is coupled to a connector 159 to facilitate coupling of the tube to a connector 102a on support plate 64. Torso section 150 is that section which will provide percussion and vibration therapy to the patient through selective rapid inflation of each cell 151. Torso section 150 includes a plurality of snaps to engage complimentary snaps 161 on adjacent sections. Section 150 also includes a coupling 153 to couple envelope 155, through tubing, to a connector member 102b. (Such connector will couple, for example, to a complimentary connector as indicated at 534 in FIG. 4).

Referring now to FIGS. 14A-D, therein is shown a section of overlay assembly 94 as may be utilized for either of sections 152 or 154 for the seat and thigh portions of the patient's body, respectively. Each section 240 is divided into three distinct chambers 242, 244, and 246. As previously described, outer chambers 242 and 246 serve as bolsters to assist in retaining a patient centralized upon overlay assembly 94. Central chamber 244 is independently adjustable in pressure through an inlet 248 to establish optimal comfort and/or interface pressures for the patient.

Referring now to FIGs. 15A-D, therein is depicted an exemplary cushion 157 as is used, in a set of three, to form foot section 156 of overlay 94. Each cushion 157 includes three chambers 173, 175, and 179. Outer chamber 173 and 179 form bolster chambers, while central chamber 175 will support the patient's feet. Each cushion 157 includes a plurality of snaps by which the cushion will couple to an adjacent cushion or section, or the fabric panel 90. Each chamber includes a connector to facilitate fluid couping the support plate 64 in the manner previously described.

The use of separate cushion to support the patient's feet allows the feet to slip between the cushions to avoid localization of pressure on the back of the heel by allowing substantial support of the foot to come from the support of the bottom of the foot on a cushion; thereby reducing the likelihood of breakdown of the patient's skin.

Referring now to FIG. 16, as stated previously, bed 20 is controlled through use f control panel 36 including a liquid crystal display 540 accompanied by a plurality f touch-sensitive membrane switches 542. Switches 542 provide the data input medium for the microprocessor in control panel 36 controlling the functions of bed 20. In one preferred implementation of the invention, control panel 36 includes a 32 bit Motorola 68331 microprocessor to control functions of bed 20. Bed operating parameters are preferably contained within a 1 or 4 Mbit EPROM to facilitate program changes. A real time clock module provides time and date for software functions and preferably includes 114 bytes of non-volatile RAM for maintaining selected control panel data when power is removed.

Referring now to FIG. 30, therein is depicted a block diagram of the electrical system 220 of bed 20. Electrical system 220 includes control panel 36 as previously described. A power distribution board 228 provides an interface between control panel 36 and other control devices, including: the proportional valves 50 controlling airflow to each channel in the bed, a seat dump valve (described in reference to FIGS. 28A-C); pressure transducers; blower; side guard position switches, head elevation sensors, and various other functions. To provide this interface, power distribution board 228 includes a microcontroller. Pressure feedback tubes (56a-j in FIG. 7) couple to pressure transducers on power distribution board 228 to facilitate monitoring and precise control of air pressures in cells in upper inflatable level 92 and lower inflatable level 74. In addition to the proportional valve feedback, as previously described feedback of the main air pressure manifold is communicated to power distribution board 228 through a pressure feedback tube (56k in FIG. 7), to facilitate control of blower 40. Some input

signals to power distribution board are voltages which are then each converted to a digital signal and communicated to the microcontroller on the power distribution board 228. Similarly, a digital to analog converter on the power distribution board receives digital signals from control panel 36 (and in particular from microprocessor 229 therein), and converts the signals into analog voltages to establish parameters, such as, for example, the proportional valve position (and resulting pressure output), and the blower speed.

Electrical box 230 receives input AC power and communicates that power both to the hydraulic controller circuitry which controls hydraulic functions of the bed, and also provides 24 to 27 volt DC current to operate blower 40, a cooling fan, and further to voltage reducers providing 12 and 5 volts DC current for operation of electronics in bed 20. A scale board 234 interfaces with a plurality of load cells (preferably 4 load cells) on bed 20 to facilitate monitoring a patient's weight. Cable interface board 236 provides a junction point for cables to interconnect the various control unit components, including those of the bed frame 26, itself (see 231, 233).

Referring now to FIG. 17, therein is depicted a flowchart 240 of the patient pressure baseline setup routine implemented through control panel 36 by the microprocessor 229 therein. As can be seen, to ready the bed for a particular patient, inputs will be provided for the patient's height 242 and weight 244. Based upon such inputs, control panel 36 determines initial baseline zone pressures 246 for the working cushions of lower support layer 74 and for overlay assembly 92, based upon predetermined criteria. Such criteria are well-known in the industry, and are a matter of design choice. Once the predetermined baseline pressures are established, in each

zone the pressure may be varied by the caregiver to define a pressure baseline specifically tailored to the individual patient. Typically, pressures f the working cushions will be equal within each cushion group 78, 80, 82; and will typically rang between 0 and 20 inches of water. Each of the preestablished zones in upper overlay assembly 94 will be adjusted to provide optimal interface pressure and patient comfort. To achieve this, once predetermined baseline pressures are determined 246, for each zone and control panel 36 will communicate, through power distribution board 228 to operate proportional valves 50 to establish all cushion pressures at the predetermined baseline level 248. At such time, the pressures may be individually customized through control panel 36 to vary pressures in individual zones 250, or to adjust zone levels as necessary to achieve optimal patient comfort 252. Once setup has been completed, any desired therapy may be selected 254.

Referring now to FIG. 18, therein is depicted a flowchart for blower pressure setup routine 256. Where a therapy other than static support is selected for the patient, control panel 36 will adjust the blower pressure as appropriate. As can be seen in FIG. 18, when rotation therapy is selected 258, the blower pressure will be established to eight inches of water above the maximum zone pressure established during the setup procedure 240. However, if relaxation therapy is selected 262 then the blower pressure will be established to six inches of above the maximum zone pressure established 264 during setup 240. Where vibration therapy is selected 266, percussion therapy is selected 268, or a combination of vibration and percussion therapy is selected 274, then in each circumstance, the blower pressure will be established to eight inches of water above the maximum zone pressure, 270, 272, respectively. In the absence of any

therapy being selected 276, then the blower pressure will be merely established to six inches of water above the maximum zone pressure and such level will be maintained during standard mode therapy 278.

Referring now to FIGS. 19A-F, therein is depicted flowchart of an exemplary rotation routine 280 for controlling rotation of a patient on bed 20. Where rotation therapy was selected (see FIG. 17) and the blower has been appropriately established (see FIG. 18), then determined parameters regarding the speed of rotation in both a downward direction ("down slew rate") and an upward direction ("up slew rate") will be loaded 282 from predetermined data based on the patient's height and weight. In one preferred embodiment, the down slew rate will be approximately 0.5 inch of water/ second; while the up slew rate will be approximately 0.1 inch of water/second. Subsequently, rotation of the patient to the left side will be initiated by decreasing the left working cushion pressure at the down slew rate, and by increasing the right cushion pressure at the same "up slew rate" while maintaining center cushion pressure at baseline 284. During these changes, the pressures of overlay assembly 94 will remain essentially constant, while the pressures extending longitudinally down the entire length of the working cushions will preferably be varied at the preselected uniform rate. These changes will continue until a selected lower pressure is reached 285 in the (decreased pressure) left cushions. A determination is made if the rotation boost option has been selected 286. If so, the center cushion pressure will be decreased 287 for a predetermined period, for example, fifteen seconds. The center cushion pressure will then be increased to equal that of the right side pressure 288 to complete rotation of the patient. Once the center working cushion pressure is equal to that

f the right working cushi n pressure, a pause is preferably included to all w the patient to remain in such position for a preestablished period of time 290. After the expirati n f the predetermined pause period is determined 292, then control panel 36 initiates functions to center the patient, or to return the patient to a generally horizontal position. This function occurs: (1) by decreasing the center cushion pressure to the established baseline pressure at the predetermined "down slew rate"; (2) by decreasing the right side working cushion pressure to the established baseline at the up slew rate; and (3) by increasing the left side working cushion pressure to the established baseline at the up slew rate 294. Once the baseline pressures are reached 296, then the left side working cushion pressure will be increased to 1.5 times the baseline pressure 298; and will subsequently then be decreased 300 until the left side working cushion pressure is again at the determined baseline 302, thereby establishing true horizontal positioning of the patient. Again, a pause will preferably be effected 304 to maintain the patient in the horizontal position for a predetermined time period. Once the predetermined pause time 304 has expired 305, then rotation of the patient to the right side will be initiated. This is done by decreasing the right working cushion pressure at the down slew rate while increasing the left working cushion pressure at the up slew rate while maintaining the center cushion pressure at baseline 306. Once the desired pressure is reached in right working cushion 308 then a determination is again made if the rotation boost option has been selected 309. If so, the center working cushion pressure will be decreased for a selected time period 310, and will then be increased in pressure to match that of left working cushion pressure 311, thereby completing rotation, and pausing for a predetermined period 312. Once the pause time has expired 314 the process will begin to again center the patient by decreasing the center working cushion and the

left working cushion pressure to baseline at the down slew rate, while increasing the right working cushion pressure to baseline at the up slew rate 316. Once the baseline pressures are reached 318, then the right side w rking cushion pressure will be increased to 1.5 times the baseline pressure 320 and then be decreased 322 until the baseline pressure is reached 324, and a pause will then again be initiated at the center position 326.

Referring now to FIG. 20, therein is depicted a flowchart for a relaxation, or pressure relief, therapy routine 328. Relaxation therapy will function by changing pressures within entire zones within overlay assembly 94. When relaxation mode is entered, the chest zone and the seat zone will each be set to atmospheric pressure 330. After a pause for a predetermined time period, preferably 30 seconds, 332; the chest zone and the seat zone will be returned to baseline pressure 334. After another pause, again preferably for 30 seconds, 336, the thigh zone and the foot zone will be decreased to atmospheric pressure 338. After another pause, again preferably for 30 seconds, 340; the thigh zone and foot zone will be returned to baseline pressure 342 and another pause will be initiated 344.

Referring now to FIG. 21, therein is depicted a flowchart for an exemplary routine for implementation of percussion therapy 346. In the percussion therapy routine, determination is first made as to whether left rotation was selected 348. If left rotation was selected, then the patient is rotated to the left in accordance with the flowchart of FIG. 18A. Alternatively, if it is determined that right rotation was selected 350, then the patient is rotated to the right in accordance with FIG. 18C. Alternatively, of course, the patient may be merely retained in a

horizontal position. Once the patient is in the desired position, the operator selected percussion frequency is input 356. The boost solenoid (480 in FIG. 31) is then opened 358, and after a delay of one half f the preselected percussion frequency 360, the boost solenoid will be closed 362. The vent solenoid (481 in FIG. 31) will then be opened, and after again a delay of one half of the preselected percussion frequency, the vent solenoid will be closed. The sequence will then be repeated 370 for the desired duration of the percussion therapy.

Referring now to FIG. 22, therein is depicted a flowchart for an exemplary routine 372 for implementation of vibration therapy. Vibration therapy is essentially identical to percussion therapy, with the exception that the percussion will operate at approximately 1-5 cycles per second; while vibration will cycle at approximately 6-25 cycles per second. In the vibration therapy routine 372, determination is first made as to whether left rotation was selected 374. As with percussion, if left rotation was selected, then the patient is rotated to the left 376 in accordance with the flowchart of FIG. 18A. Alternatively, if it is determined that right rotation was selected 378, then the patient is rotated to the right 380 in accordance with FIG. 16C. Alternatively, of course, the patient may be merely retained in a horizontal position. Once the patient is in the desired position, the operator-selected vibration frequency is connected to the power distribution board for controlling valve operation 382. The boost solenoid (480 in FIG. 31) is then opened 384, and after a delay of one half of the preselected vibration frequency 386, the boost solenoid will be closed 388. The vent solenoid (481 in FIG. 31) will then be opened 390, and after again a delay of one half of the preselected vibration frequency 392, the vent

solenoid will be closed 394. The sequence will then be repeated 396 for the desired duration of vibration therapy.

Referring now to FIG. 23, therein is depicted a flowchart for combination percussion/vibration therapy 398. If the combination percussion/vibration therapy mode is selected, then percussion therapy will be instituted in accordance with percussion routine 346 of FIG. 20. At such time as the preestablished percussion duration has elapsed 402, then vibration therapy will be instituted 404, in accordance with flowchart 372 of FIG. 21. Once the predetermined vibration therapy period has elapsed 406 then the patient will be returned to standard mode therapy 408.

Referring now to FIGS. 25A-B, therein is depicted an exemplary embodiment of a manual release connector 102, as is described earlier herein, as being particularly useful for providing connections wherein hoses are to be coupled. Connector 102 includes a male member 420 and a female member assembly 422. Male member 420 includes an extending portion 424 which includes two circumferential grooves 426, 428. Longitudinally outermost circumferential groove 426 houses an O-ring 430 by which to assure a sealing engagement with a complementary bore 434 within female member 422. Second circumferential groove 528 is designed to align with a retaining plate 432 forming a portion of female member assembly 422. Retaining plate 432 includes an elliptical aperture proximate an entrance to interior bore 434 of female member 422. Retaining plate 432 is resiliently loaded, such as by a spring (not illustrated), such that in an unactuated condition, retaining plate 432 extends partially across the

opening to internal bore 434. When male member 420 is operably coupled to female member 422, retaining plate will at such time engage circumferential groove 428 n male member 422 and thereby retain the two members in interlocked and operative relation to one another. Subsequent movement of retaining plate 432 will move plate 432 out of engagement with groove 428 and allow release of male member 420 from female member 422. In most applications, male member 420 and female member assembly 422 will each include fluted connecters 436, 438, respectively, to facilitate coupling of hoses or similar apparatus to each member.

Referring now to FIGS. 28A-C, therein is depicted an exemplary embodiment of a dump valve 439 appropriate for use with the present invention. As previously discussed, the purpose of dump valve 439 is to evacuate air from the seat section working cushion group 80 to facilitate patient ingress and egress. Dump valve 439 includes a valve block 440, having three axially aligned valve sections 441, 442, 444, which is operatively coupled, such as by bolts to support plate section 70. Coupling of valve block 440 to support section 70 brings pairs of valve apertures 446a, b; 448a, b; and 450a, b into registry with corresponding apertures 452a, b; 454a, b; and 456a, b, respectively, in support section 70. A rotating valve member 458 is operatively coupled, such as through shaft 460 and a slip clutch to an electric motor 462, configured to selectively initiate rotation of valve member 458 in response to control panel 36 or another switch mechanism. Rotation of valve member 458 is approximately 90 degrees relative to valve blocks 440, 442, and 444. Rotating valve member 458 includes three generally L-shaped passages (one depicted at 464 in FIG. 28A) which are spaced such that in a first position (see FIG. 28B) one leg 447 of the L-shaped profile interconnects pairs of apertures (for

example 446a and b; while in a second position (see FIG. 28A), the other leg 449 of the L interconnects one of the apertures (for example 446b), with the corresponding vent aperture for that block (see 447). Thus, when valve block 458 is in the described first position, air (for example, from outlet 452a in FIG. 4) will enter an aperture (e.g., 446a), and will be communicated directly to an outlet aperture 446b coupled to working cushions of seat section cushion group 80 (i.e., cushions 180) through the corresponding aperture (e.g., 452b) in support plate member 70. However, upon actuation of motor 462 to rotate valve member 458 to the position depicted in FIG. 28A, those working cushions (180) will be coupled (through aperture 452b), through segment 449 in valve member 458 to vent aperture (e.g., 451) causing deflation of the connected working cushions.

Referring now to FIG. 30, therein is depicted an exemplary assembly as may be utilized to provide fluid communication between support plate assembly 64 and portions of overlay assembly 94. In particular, the depicted assembly is of a type as would be utilized to provide fluid communication between support plate assembly 64 and the bolster sections of foot cushions 157 (see FIG. 3). A dome connector 502 is preferably adhesively coupled to support plate assembly 64. A connector member 504 is threadably coupled to dome connector 502. Connector member 504 may be fitting as manufactured by Colter Products Company of St. Paul, Minnesota, and identified as Part No. PLC240-04. A complimentary connector 506, such as CPC fitting model PLDC170-06 (see FIG. 25) will then be utilized to provide fluid communication through a length of appropriate tubing 508 to a T fitting 510. Lengths of tubing 512 and 514 will then be utilized to provide further fluid communication. Specifically, tubing

512 will be connected through an elbow fitting 516 (such as CPC model PLCD230-06) and through another length f tubing 518 to a releasable female coupling 520a. This releasable coupling may form an assembly, such as is depicted in FIG. 25, which will be connected to either through a length of tubing (522, as depicted) or directly to an appropriate cell or chamber in overlay assembly 94. Similar connections will be provided for each fitting 520a-c. Each tubing/fitting coupling may be secured through use of a clamp, such as a conventional hose clamp. When such a clamp is utilized, it is preferred that the clamp be covered with a protective material, such as shrink-tubing or another wrap material, to protect the surfaces of adjacent inflatable cells.

Referring now to FIG. 32, therein is depicted an assembly 103 as is utilized to secure the outermost working cushions of each cushion group 78, 80, and 82 to support surface 64, and to provide fluid communication to each cushion. Each cushion includes a fitting 103b having a circumferential retaining disc 542 extending therefrom. The lower end 546 of the elbow will fit into a receiving bore 543 in a receptacle 103a adhesively second to support plate assembly 64. A retaining clip 546, having generally C-shaped engagement apertures 548 and 550 will then be utilized to get engage a circumferential groove 552 on receptacle 544 and circumferential disc 542 on elbow fitting 541 to retain the two pieces in engaged relation.

As is apparent from the disclosure above, the preferred embodiment facilitates the establishing of desired interface pressures, coupled with a low air loss surface, and lateral support, or cradling, through use of a multi-zoned inflatable overlay; and further facilitates

lateral positioning f the patient through use of a lower level f inflatable cells. Many modifications and variations may be made in the techniques and structures described and illustrated herein without departing from the spirit and scope of the present invention. For example, the lower inflatable level may be formed of one or more multi-celled units. Similarly, additional zones may be defined in either the upper or lower inflatable levels to achieve such degree of control as may be desired. Additionally, the lower inflatable level itself has utility for supporting a patient directly, without the intervening upper inflatable support layer (in which case portions of the lower inflatable layer may provide for air flow, as desired). Accordingly, it should be readily understood that the structures and methods described and illustrated herein are illustrative only, and are not to be considered as limitations upon the scope of the present invention.

WHAT IS CLAIMED IS:

1. A patient support surface, comprising:

a support assembly;

a first longitudinal cushion set coupled to said support assembly, said first longitudinal cushion set including a plurality of generally parallel cells, and extending a portion of the longitudinal length of said support assembly;

a second longitudinal cushion set coupled to said support assembly, said second longitudinal cushion set including a plurality of generally parallel cells and also extending a second, longitudinally offset portion of the longitudinal length of said support assembly; and

an inflatable support layer disposed generally above said first and second longitudinal cushion sets.

2. The patient support surface of claim 1, further comprising a third longitudinal cushion set coupled to said support assembly, said third longitudinal cushion set including a plurality of generally parallel cells and extending along a third, further longitudinally offset part of the longitudinal length of said support assembly.

3. The patient support surface of claim 1, wherein said inflatable support layer comprises a plurality of separately inflatable zones.

4. The patient support surface of claim 3, wherein said inflatable support layer extends generally over the entire length f said first and second longitudinal cushi n sets.

5. The patient support surface of claim 1, wherein said support assembly includes a generally solid surface for supporting said cushions, said generally solid surface including at least two generally transverse articulation points to facilitate articulation of said support assembly.

6. The patient support surface of claim 2, wherein said support assembly includes a generally solid surface for supporting said cushions, said generally solid surface including at least two generally transverse articulation points to facilitate articulation of said support assembly.

7. The patient support surface of claim 1, wherein said first and second sets of longitudinal cushions are constructed of material generally impervious to the flow of air therethrough.

8. The patient support surface of claim 1, wherein said inflatable support layer comprises a low air loss portion constructed to provide a flow of air adjacent a patient supported thereon.

9. The patient support surface of claim 1, further comprising:

a supply of air; and

a selectively controllable manifold operably coupled to said supply of air and to said first and second sets of longitudinal cushions and to said inflatable support layer, said manifold assembly configured to provide selective fluid communication between said supply of air and said first and second sets of longitudinal cushions and said inflatable support layer.

10. A support surface for supporting a patient comprising:

a support assembly;

a first set of inflatable longitudinal cushions coupled to said support assembly and arranged to extend partially along the longitudinal length of said patient;

a second set of inflatable longitudinal cushions coupled to said support assembly and arranged to extend partially along another, longitudinally offset, portion of the length of said patient;

a patient contacting assembly retained between said patient and said first and second sets of inflatable longitudinal cushions; and

a supply of air in selective communication with said patient contacting member and with said first and second sets of inflatable longitudinal cushions.

11. The patient support surface of claim 10, wherein said first set of inflatable longitudinal cushions comprises a plurality of individual cushions arranged in generally parallel relation to one another.

12. The patient support surface f claim 11, wherein said cushions extend generally across the width f said support assembly.

13. The patient support surface of claim 11, wherein said second set of inflatable longitudinal cushions comprises a plurality of individuals cushions arranged in generally parallel relation to one another.

14. The patient support surface of claim 12, wherein said second set of inflatable longitudinal cushions extends generally across the width of said support assembly.

15. The patient support surface of claim 10, wherein said patient contacting assembly comprises an inflatable cushion assembly.

16. The patient support surface of claim 15, wherein said inflatable cushion assembly comprises an upper surface at least partially defining an air chamber, said upper surface including a plurality of apertures to allow the escape of air from said air chamber.

17. A bed for supporting a patient, comprising:

a support assembly, said support assembly including a bed frame;

a first inflatable support layer comprising a first plurality of inflatable cells, at least some of said cells inflatable generally independently of others of said cells;

a second inflatable layer disposed between at least a portion f said patient and said first support layer, said second inflatable support layer comprising a second plurality f inflatable cells, at least some of said cells of said second plurality f cells inflatable generally independently of others of said cells of said second plurality of cells.

18. The bed of claim 17, wherein said cells of said first inflatable support layer comprise a plurality of discrete cushions.

19. The bed of claim 18, wherein said cells of said first inflatable support layer extend generally longitudinally along said support assembly.

20. The bed of claim 19, wherein said cells of said first inflatable support layer are arranged in a plurality of laterally offset groups.

21. The bed of claim 19, wherein said cells of said first inflatable support layer are arranged in both laterally offset and longitudinally offset groups.

22. The bed of claim 21, wherein said support assembly further comprises a support surface assembly which functions as a manifold for supplying air to at least some of said cells of said first and second support layers.

23. The bed f claim 17, further comprising:

a blower for providing a supply f compressed gas for inflating at least some of said cells of said first and second support layers; and

a controller assembly for selectively controlling the inflation of selected cells of said first and second inflatable support layers.

24. The bed of claim 23, wherein said control assembly is selectively operable to alter the horizontal position of said patient at least partially through selective control of the inflation of cells of said first inflatable support layer, and is further selectively operable to control patient interface support pressures over at least a portion of said patient through selective control of inflation of said cells of said second inflatable support layer.

25. A bed for supporting a patient, comprising:

a bed frame;

a support surface coupled to said bed frame;

a first inflatable layer including a plurality of generally longitudinally extending cells, said cells arranged in longitudinally extending groups, at least one of which groups is inflatable generally independently of another laterally offset group;

a second inflatable layer including a plurality of cells, at least some of which cells are inflatable independently of others of said cells;

a blower configured to supply air at a pressure to inflate said cells of said first and second layers; and

a control assembly selectively operable to supply air to said cells to support said patient in at least one of a plurality of modes.

26. The bed of claim 25, wherein said control assembly comprises a programmable electronic controller.

27. The bed of claim 26, wherein said controller comprises a microprocessor controller.

28. The bed of claim 25, wherein said cells of said first inflatable layer are formed at least in part of discrete cushions.

29. The bed of claim 25, wherein said cells are divided into a plurality of longitudinally offset groups.

30. The bed of claim 25, wherein said cells of said second inflatable layer comprise a plurality of generally transversely extending cells.

31. The bed of claim 25, wherein said second inflatable layer is formed at least in part of an overlay assembly, and wherein said overlay assembly comprises chambers proximate the perimeter of said overlay assembly which are inflatable independently of chambers proximate the central portion of said overlay assembly.

32. The bed f claim 25, wherein said second inflatable layer is divided into a plurality f independently inflatable zones, and wherein said control assembly is selectively operable to control the pressure in each of said zones.

33. The bed of claim 25, wherein said cells of said first inflatable layer are divided into a plurality of zones and wherein said control assembly is selectively operable to control the pressure in each of said zones.

34. The bed of claim 33, wherein said control assembly is operable to control the horizontal orientation of a patient through selective control of pressures in said zones of said first inflatable layer.

35. The bed of claim 25, wherein said plurality of modes includes a mode for rotating said patient.

36. The bed of claim 25, wherein said plurality of modes includes a mode for changing the pressures in said cells of said second inflatable layer to change the interface pressures between portions of said second inflatable layer and said patient.

37. The bed of claim 25, wherein said plurality of modes comprises a percussive mode.

38. The bed of claim 25, wherein said plurality of modes comprises a vibratory mode.

39. The bed of claim 30, wherein at least a portion of said cells f said second inflatable layer are formed f discrete transverse cushions.

40. The bed of claim 35, wherein said discrete transverse cushions are arranged proximate the portion of said bed intended to support the feet of said patient.

41. A method of providing varying modes of support to a patient, comprising the steps of:

providing a first inflatable support layer having a plurality of independently inflatable zones therein;

providing a second inflatable support layer having a plurality of independently inflatable zones therein, said second inflatable support layer constructed to be independent of said first support layer, said second support layer placed between said first inflatable support layer and at least a portion of said patient;

providing a supply of compressed gas selectively controllable to each of said zones of said first and second support layer; and

selectively controlling the supply of air to each of said zones to support said patient in a predetermined support mode.

42. The method of claim 41, wherein said zones of second first inflatable support layer include a plurality of laterally offset, longitudinally extending zones, and wherein said step of selectively controlling the supply of air to each of said zones comprises the step of establishing a pressure differential between a first of said longitudinally extending zones of said first

inflatable support layer relative to another f said longitudinally extending zones to induce lateral rotation of said patient.

43. The method of claim 41, wherein said step of selectively controlling the supply of air to each of said zones comprises establishing a pressure differential between selected zones in said second inflatable support layer of a first pressure bias, and establishing a second pressure differential between said zones with the opposite pressure bias to alternate the interface pressures between said second inflatable support layer and said patient between said zones.

44. A bed having an inflatable patient supporting surface, comprising:

a support frame assembly, since support frame assembly comprising a support plate comprising a plurality of air channels therein;

a supply of air operatively coupled to selected channels of said plurality of air channels;

a valve assembly in communication with at least a portion of said plurality of air channels, said valve assembly comprising a valve block assembly, said valve block assembly defining at least two air inlets in fluid communication with selected channels of said plurality of air channels, further defining at least air outlets in fluid communication with selected channels of said plurality of air channels, and further defining at least two air vents, said valve assembly further comprising a valve rotor movable between a first position and a second position wherein in said first position said valve rotor provides fluid communication between one of said air inlets and one of said air outlets in said valve block, and

wherein in said second positi n said valve rotor provides fluid communication between one of said utlets and one of said air vents;

a plurality f inflatable cells operatively coupled to said support frame assembly, at least some of said cells being in fluid communication with said air outlets of said valve assembly.

45. The bed of claim 44, wherein said plurality of inflatable cells of said bed are distributed to form a first inflatable support surface and a second inflatable supporting surface in generally vertically disposed relation to one another.

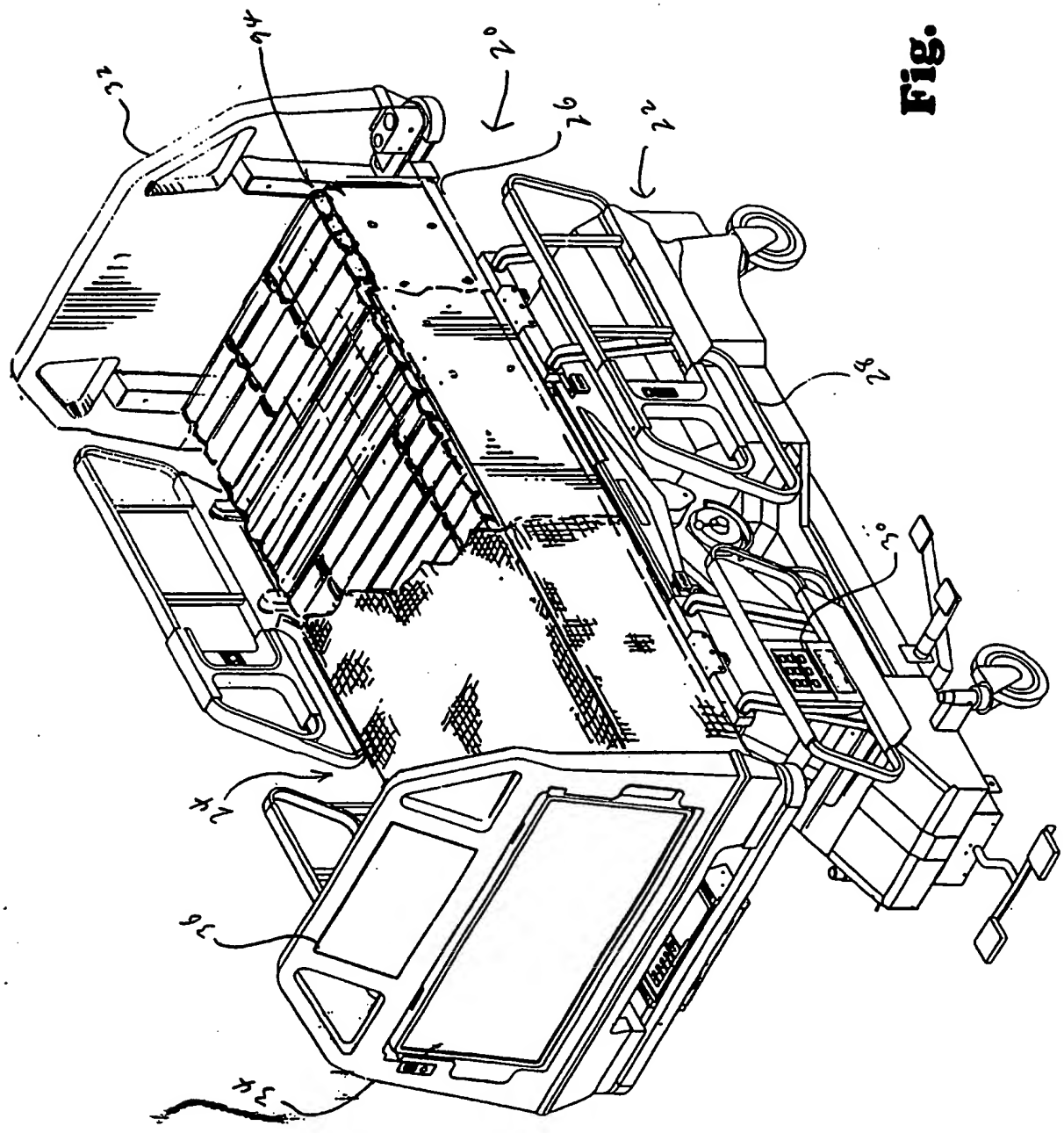


Fig. 1

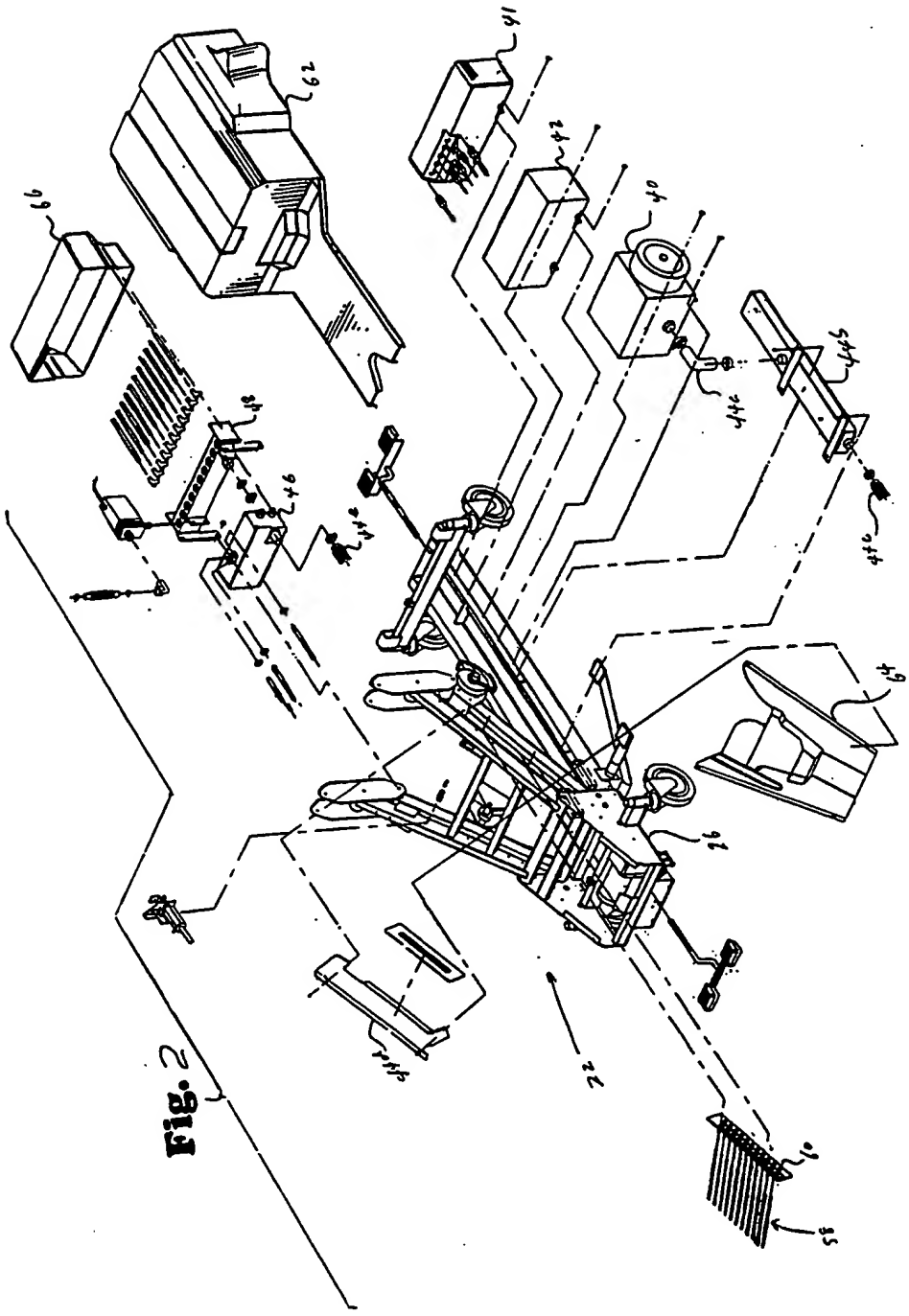
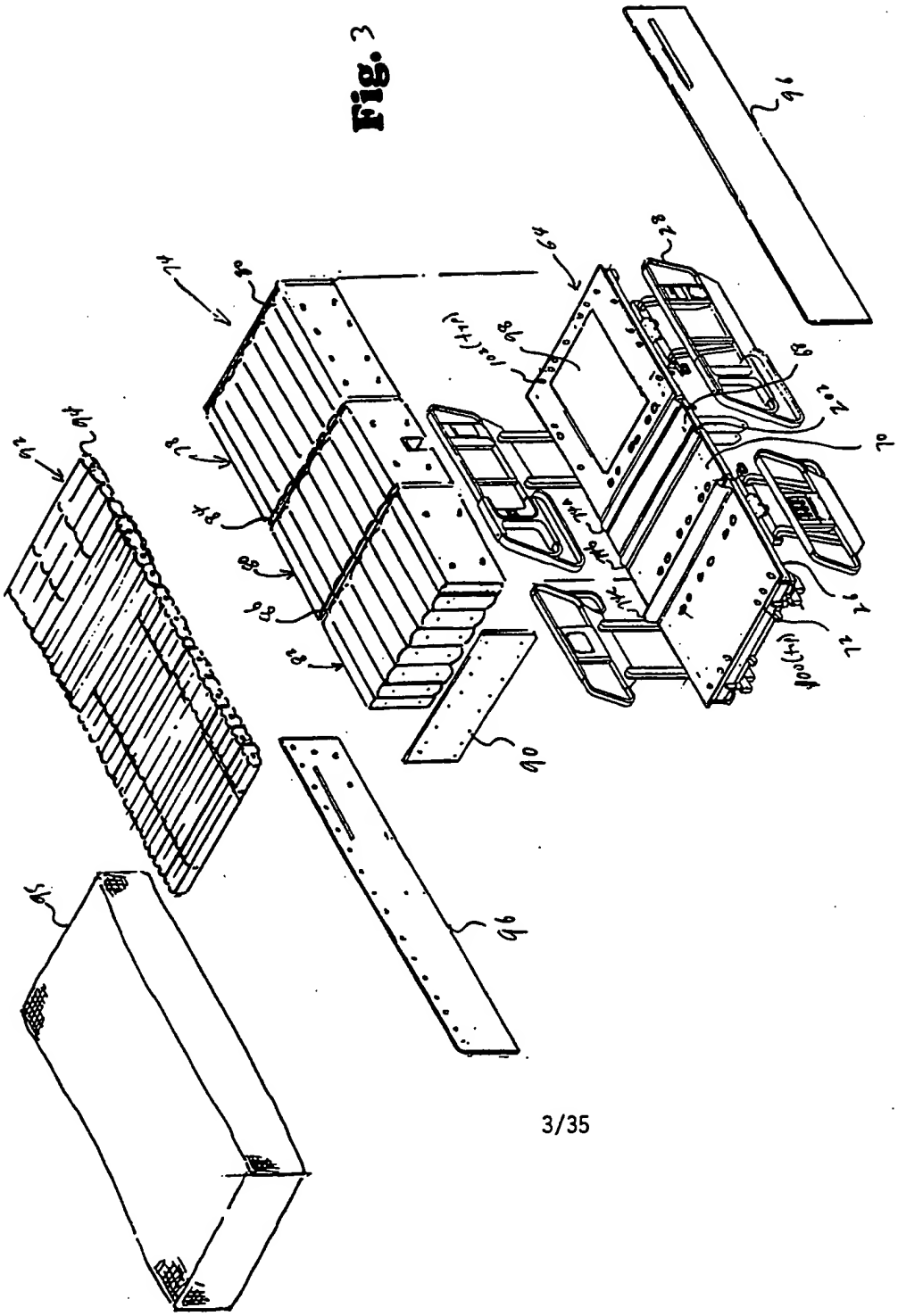


Fig. 2

Fig. 3



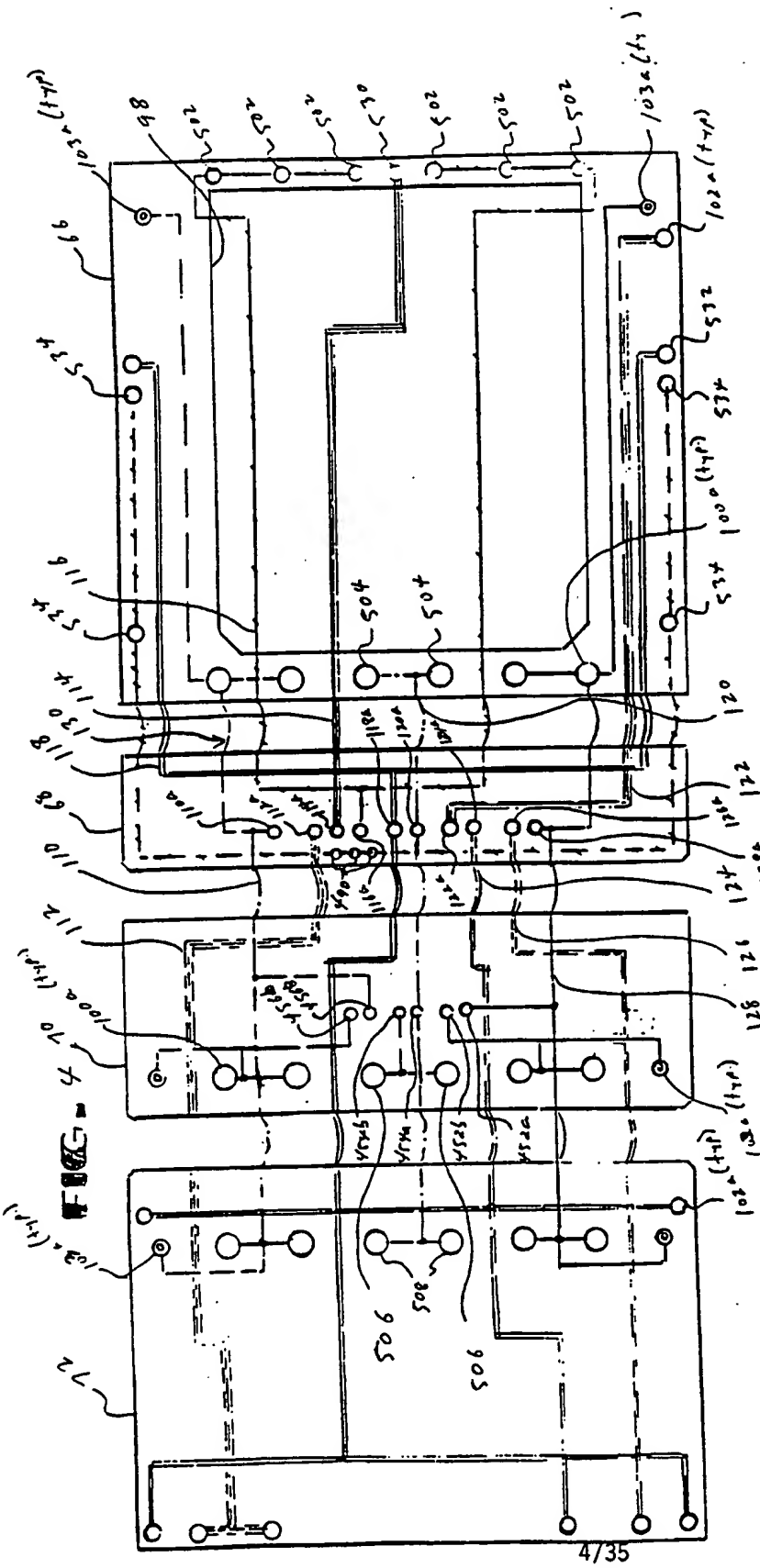

LEGEND:
VALVE #504 (MOVING CUSHION) RIGHT - 526
VALVE #502 (MOVING CUSHION) CENTER - 524
VALVE #501 (MOVING CUSHION) LEFT - 522
VALVE #501 (UPPER SURFACE, SEAT ZONE - 118
VALVE #504 (UPPER SURFACE THIGH ZONE 186
VALVE #504 (UPPER SURFACE BOLSTER ZONE - 170
VALVE #502 (UPPER SURFACE CALF AND FOOT DROP)
VALVE #504 (UPPER SURFACE FOOT ZONE - 188
AND FOOT EXTENSION)
VALVE #502 (UPPER SURFACE THIGH ZONE - 182
VALVE #502 (UPPER SURFACE, HEAD ZONE - 180
VALVE #502 (WORKING CUSHION) HEAD ZONE - 520
VALVES 498, 498 PRE CUSHION AND VIBRATION - 150

FIG - 4

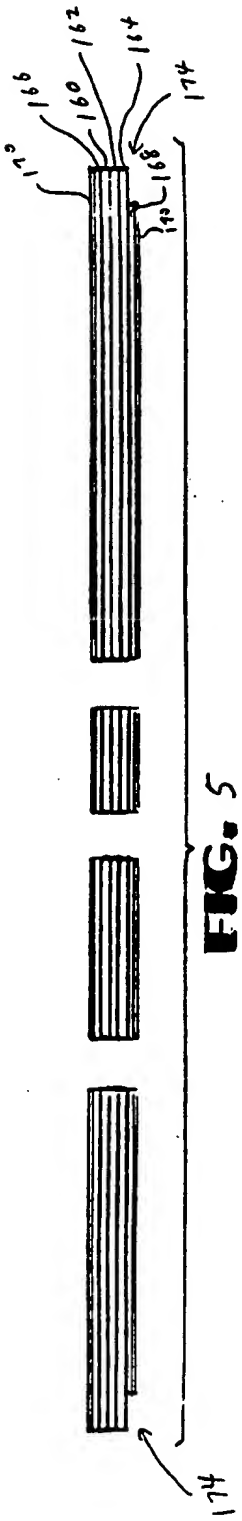


FIG. 5

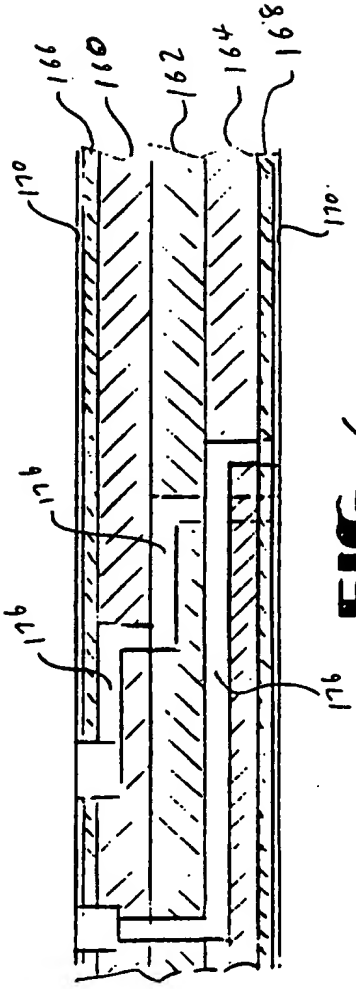


FIG. 6

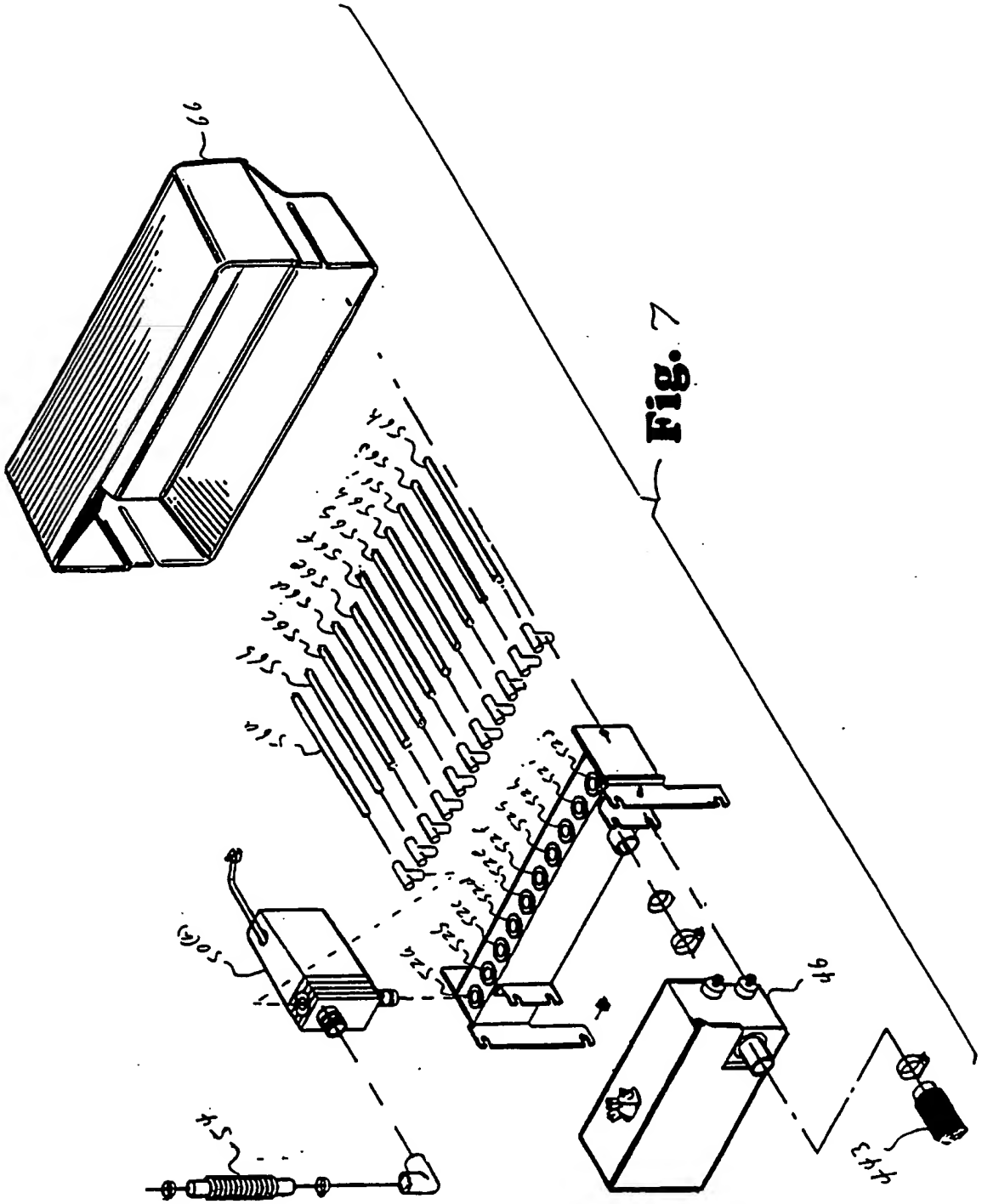


Fig. 7

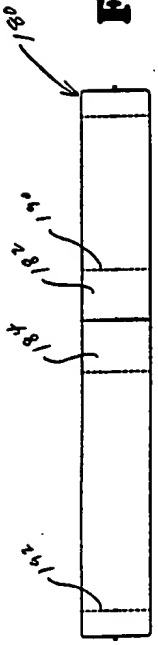


Fig. 8A

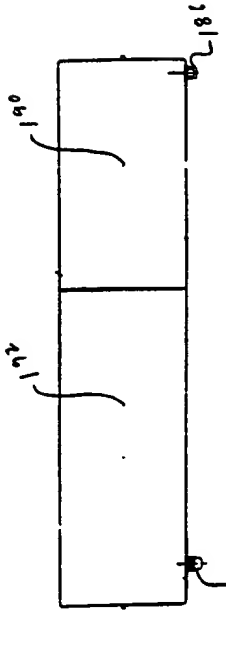


Fig. 8B

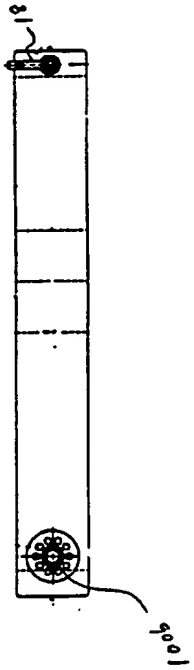


Fig. 8C

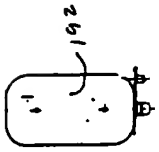


Fig. 8D

Fig. 9A

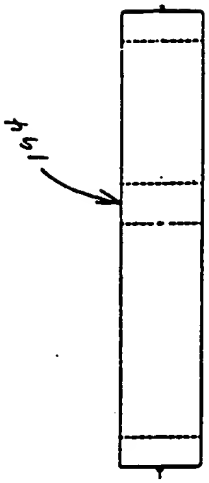


Fig. 9B

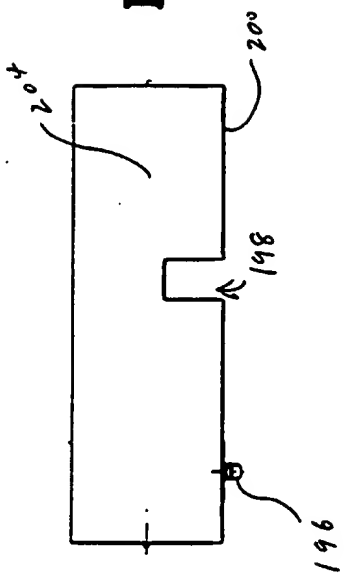


Fig. 9C

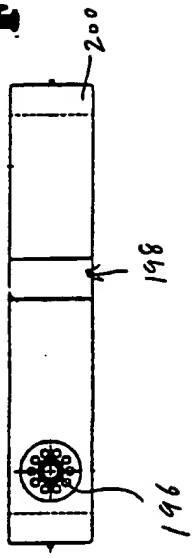
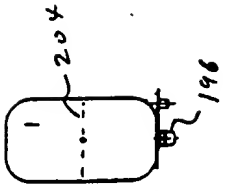


Fig. 9D



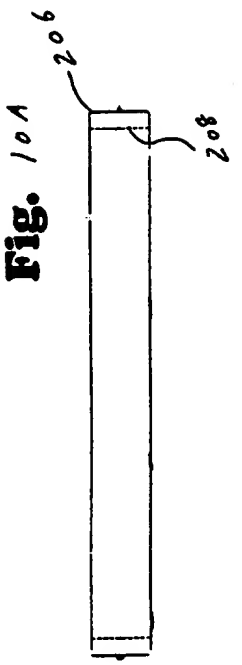


Fig. 10A

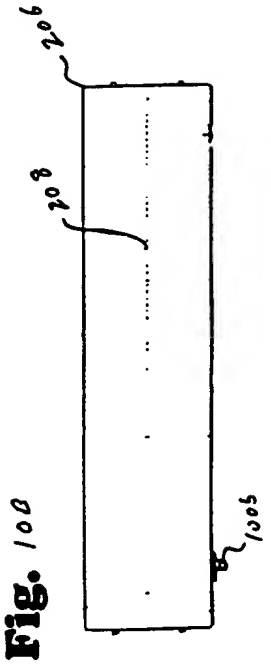


Fig. 10B

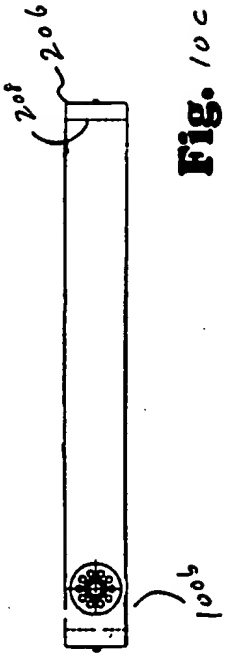


Fig. 10C

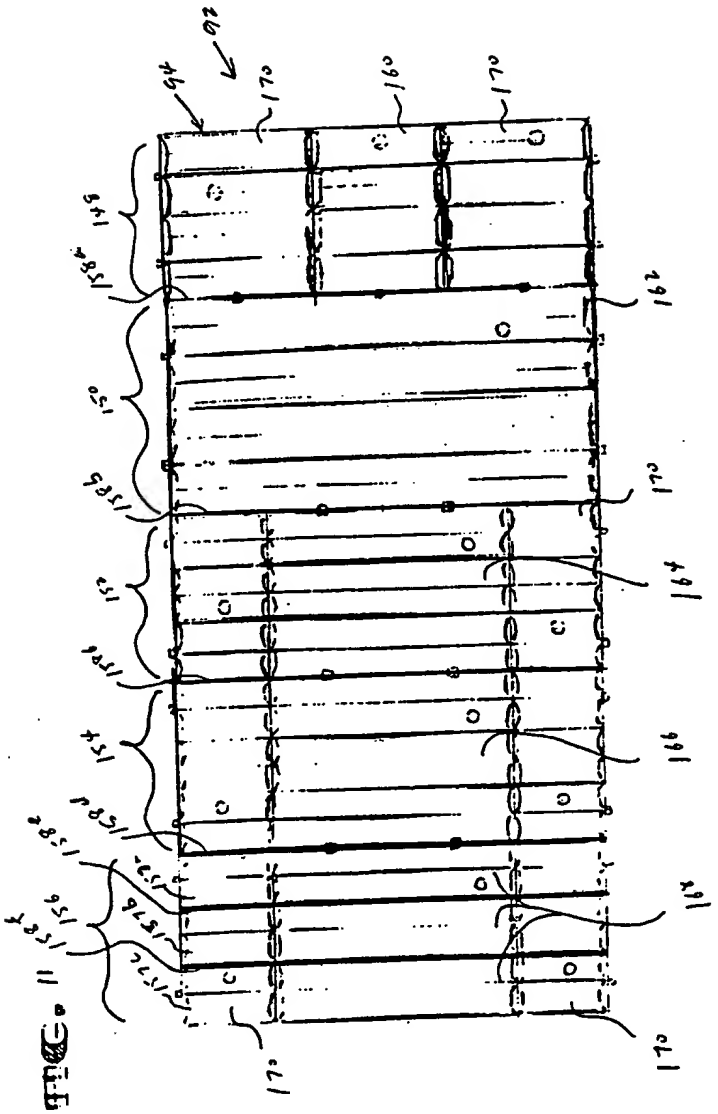


FIG. 11

Fig. 12A

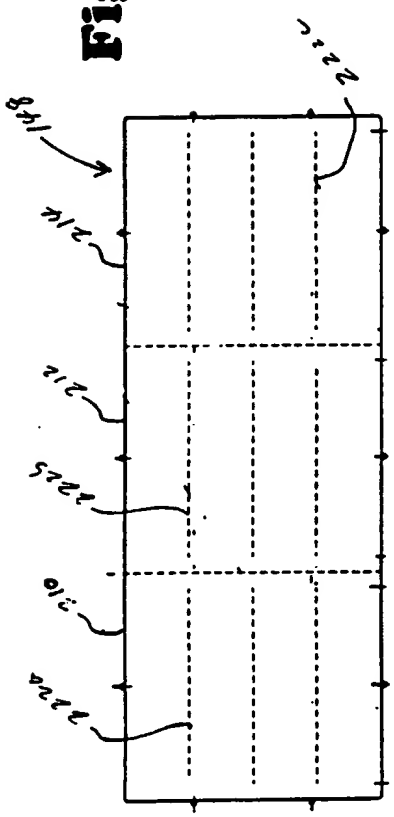


Fig. 12B

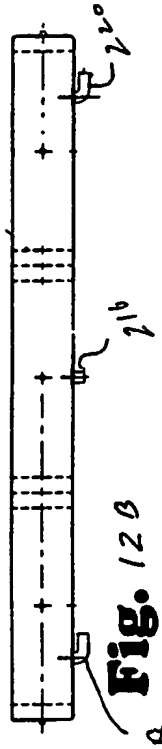


Fig. 12C

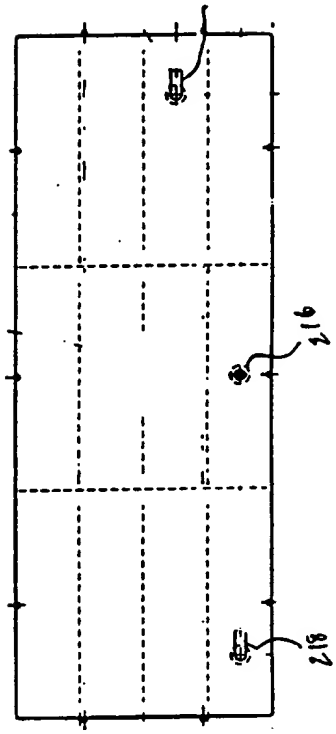
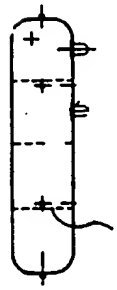


Fig. 12D



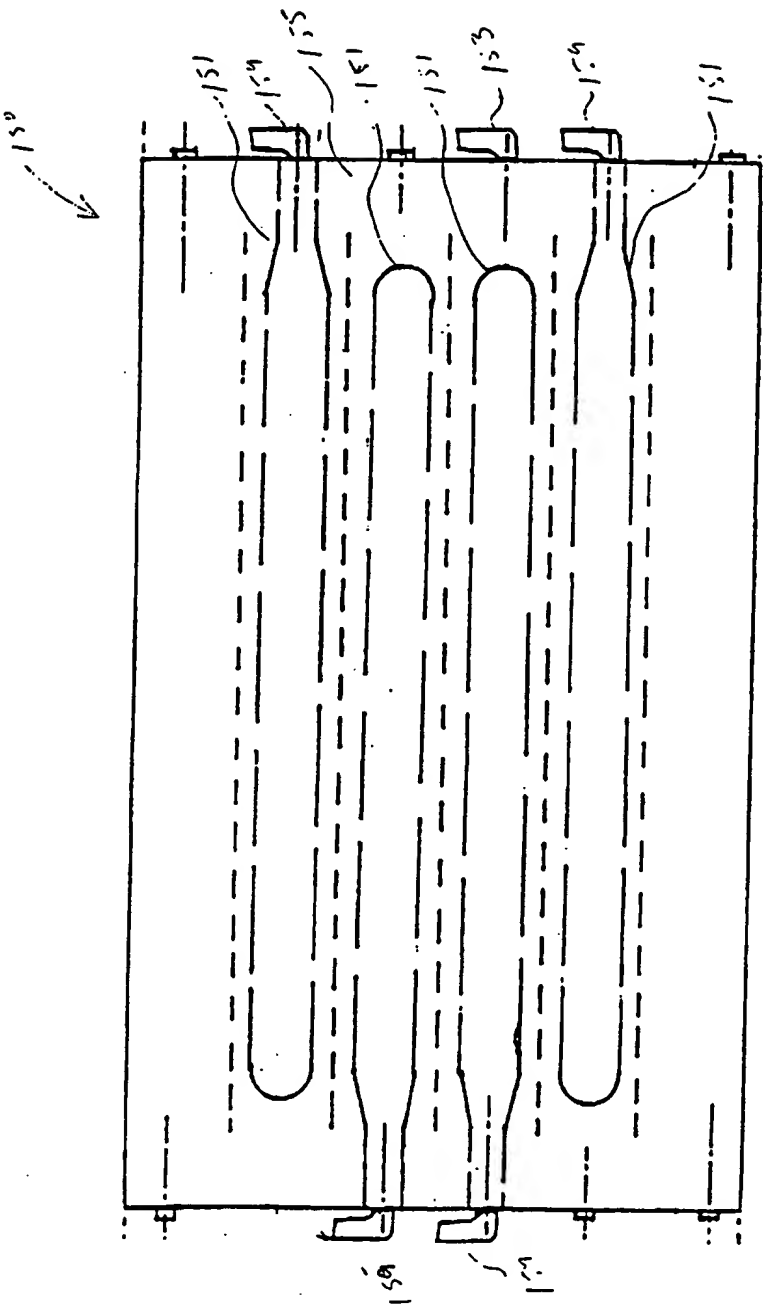


FIG 13A

FIG 13C

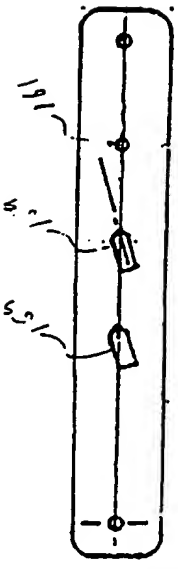


FIG 13B

VIEW "A"

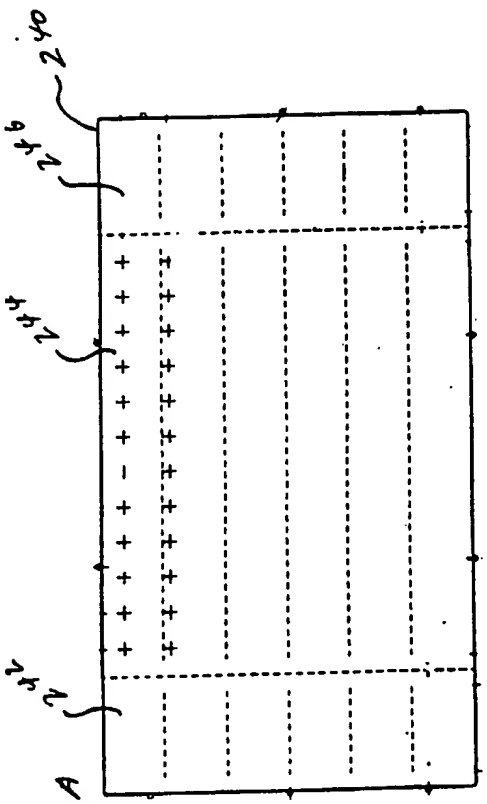


Fig. 14A

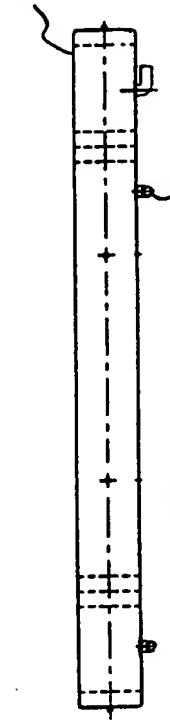


Fig. 14B

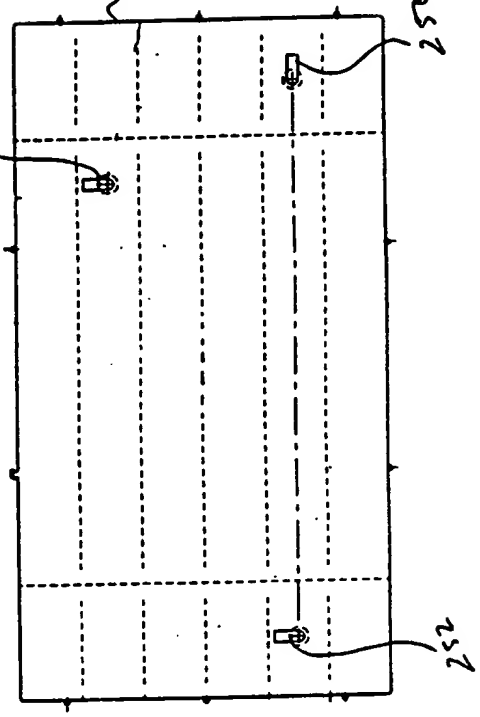


Fig. 14C

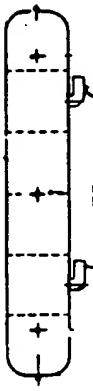


Fig. 14D

Fig. 15 D

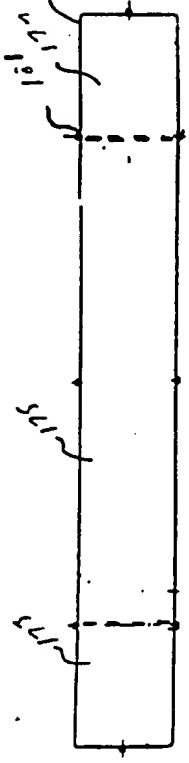


Fig. 15 A

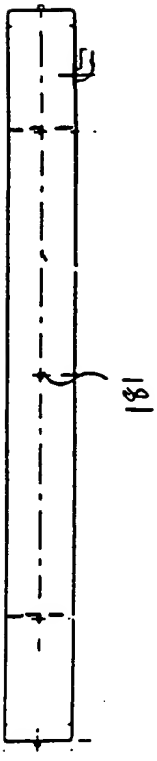


Fig. 15 B

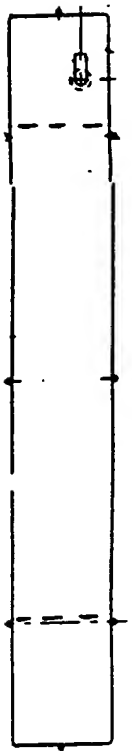


Fig. 15 C

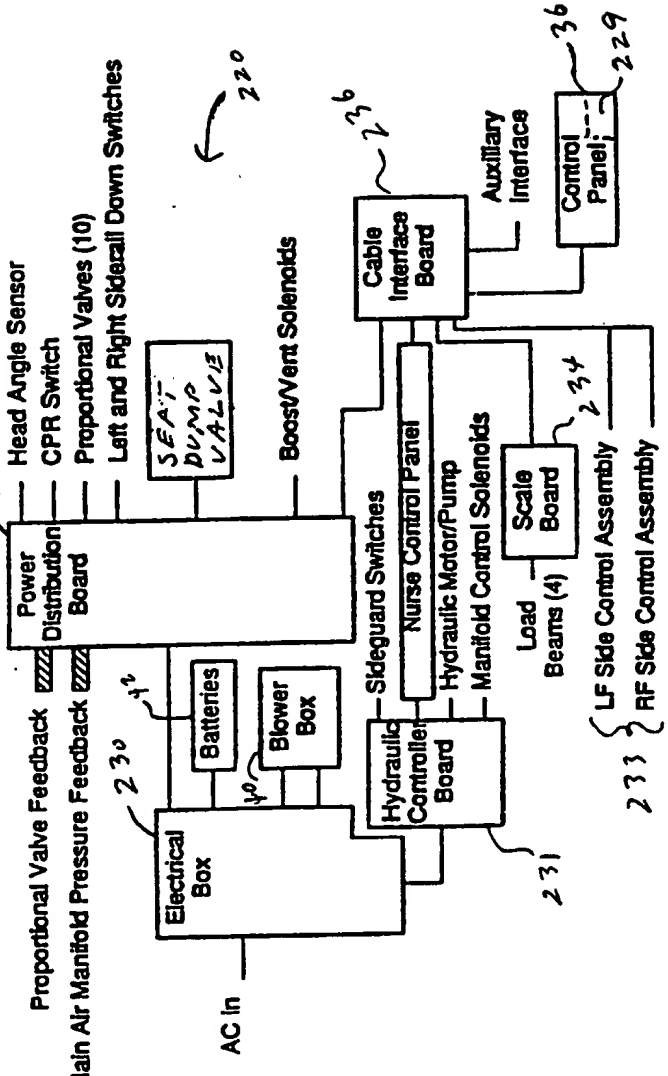

228
Head Angle Sensor
CPR Switch
Proportional Valves (10)
Left and Right Siderail Down Switches
220
SEAT DUMP VALVE
Boost/Vent Solenoids
Power Distribution Board
Cable Interface Board
226
Auxiliary Interface
Control Panel
36
229
Proportional Valve Feedback
Main Air Manifold Pressure Feedback
230
Batteries
Blower Box
Sideguard Switches
Nurse Control Panel
Hydraulic Motor/Pump
Manifold Control Solenoids
Load Beams (4)
Scale Board
234
Electrical Box
Hydraulic Controller Board
231
LF Side Control Assembly
RF Side Control Assembly
233
AC In

FIG. 16

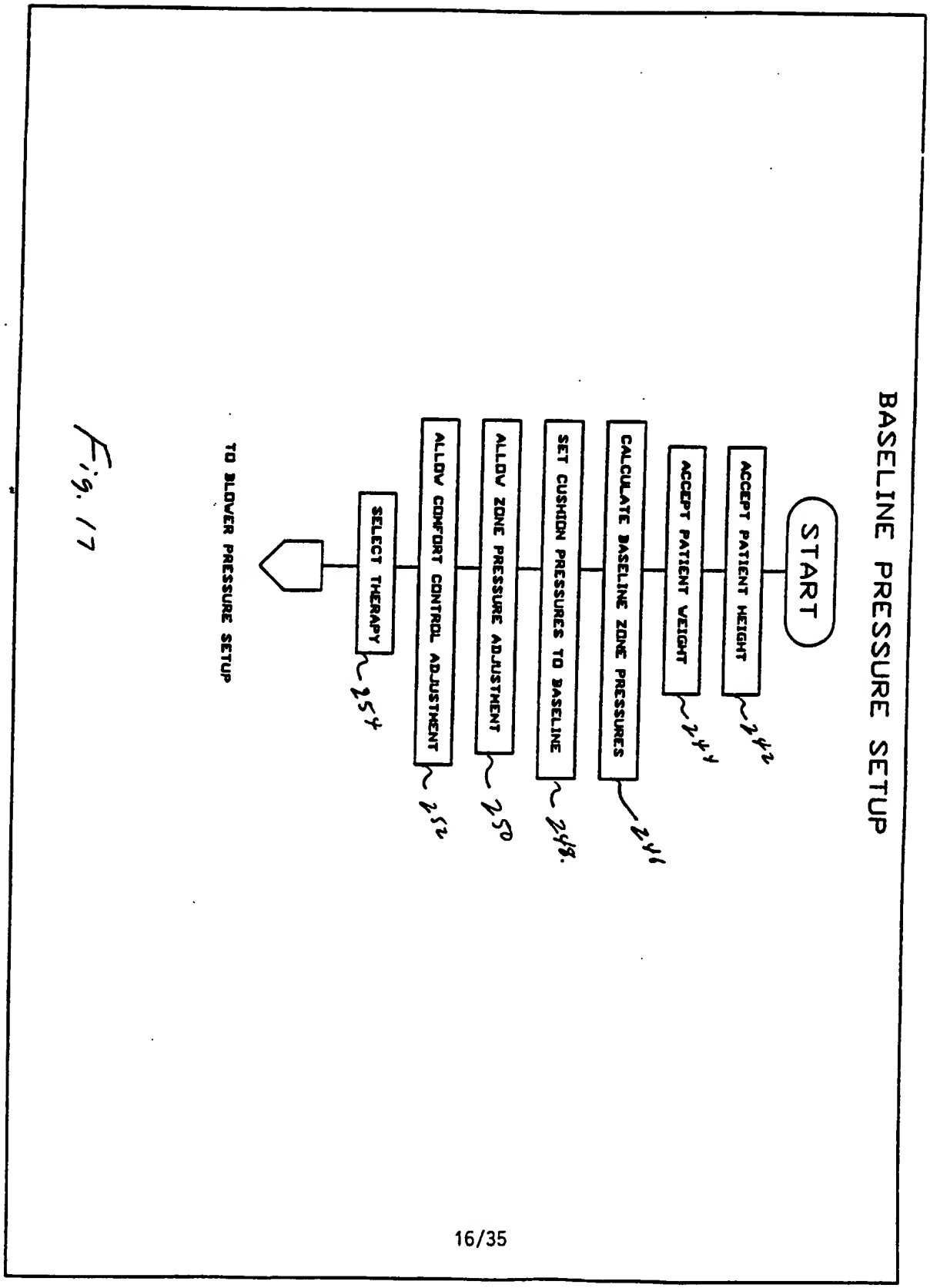

BASELINE PRESSURE SETUP
START
ACCEPT PATIENT HEIGHT
242
ACCEPT PATIENT WEIGHT
244
CALCULATE BASELINE ZONE PRESSURES
246
SET CUSHION PRESSURES TO BASELINE
248
ALLOW ZONE PRESSURE ADJUSTMENT
250
ALLOW COMFORT CONTROL ADJUSTMENT
252
SELECT THERAPY
254
TO BLOWER PRESSURE SETUP

Fig. 17

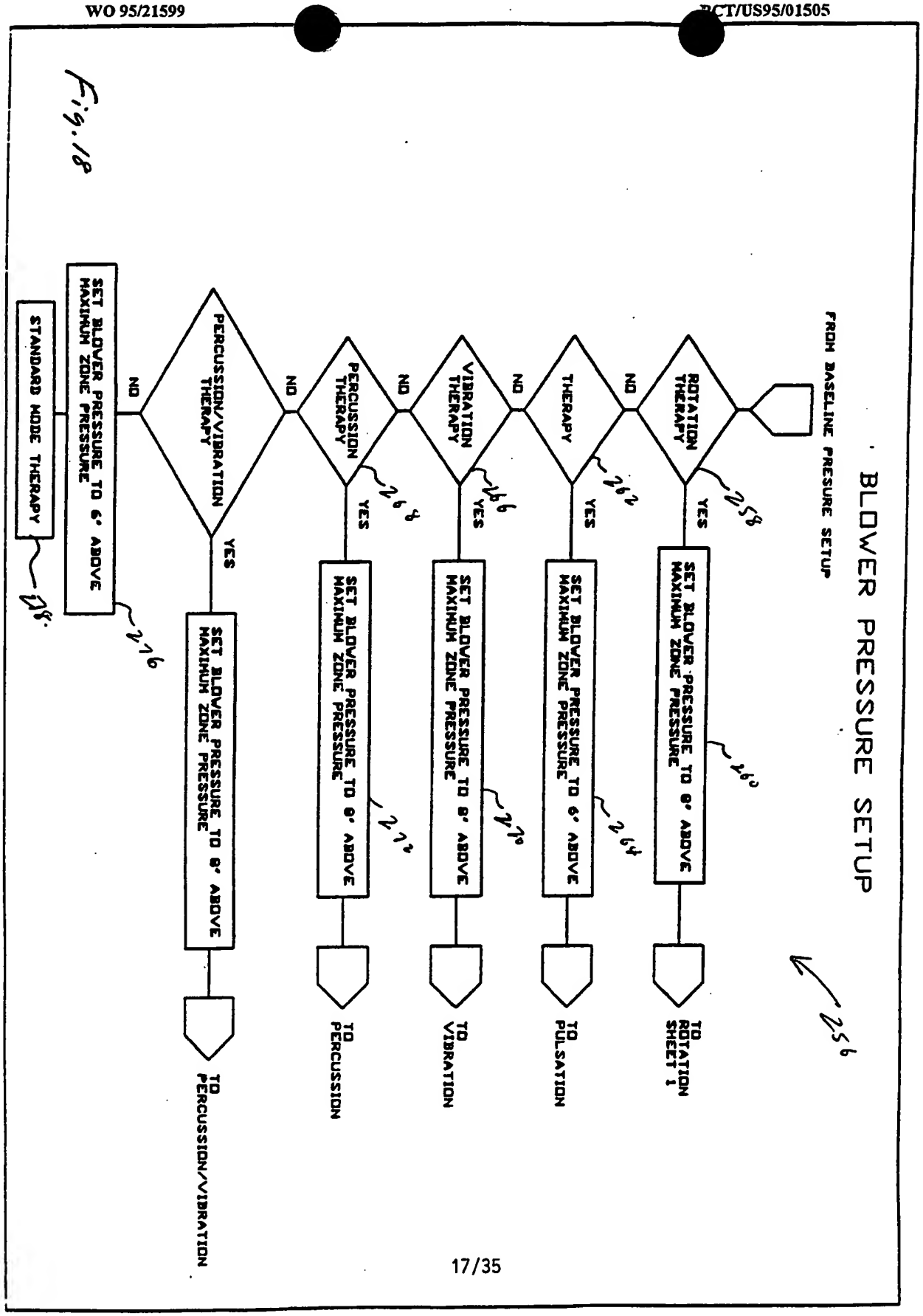

BLOWER PRESSURE SETUP
256
FROM BASELINE PRESURE SETUP
ROTATION THERAPY
YES
258
SET BLOWER PRESSURE TO 6" ABOVE MAXIMUM ZONE PRESSURE
260
TO ROTATION SHEET 1
NO
THERAPY
YES
262
SET BLOWER PRESSURE TO 6" ABOVE MAXIMUM ZONE PRESSURE
264
TO PULSATION
NO
VIBRATION THERAPY
YES
266
SET BLOWER PRESSURE TO 6" ABOVE MAXIMUM ZONE PRESSURE
270
TO VIBRATION
NO
PERCUSSION THERAPY
YES
268
SET BLOWER PRESSURE TO 6" ABOVE MAXIMUM ZONE PRESSURE
272
TO PERCUSSION
NO
PERCUSSION/VIBRATION THERAPY
YES
SET BLOWER PRESSURE TO 6" ABOVE MAXIMUM ZONE PRESSURE
TO PERCUSSION/VIBRATION
NO
SET BLOWER PRESSURE TO 6" ABOVE MAXIMUM ZONE PRESSURE
276
STANDARD MODE THERAPY
278

Fig. 18

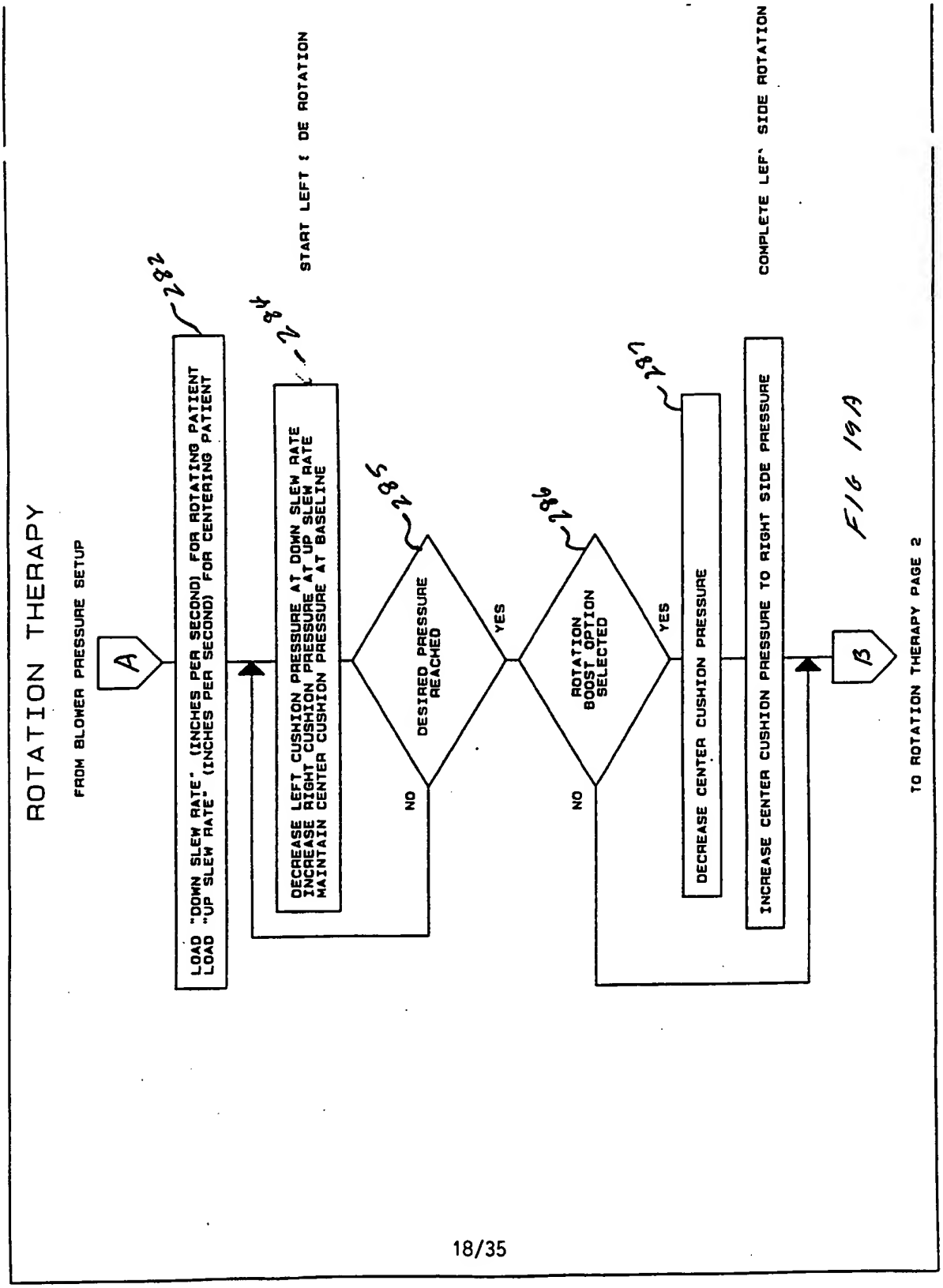

ROTATION THERAPY
FROM BLOWER PRESSURE SETUP
A
LOAD "DOWN SLEW RATE" (INCHES PER SECOND) FOR ROTATING PATIENT
LOAD "UP SLEW RATE" (INCHES PER SECOND) FOR CENTERING PATIENT
282
DECREASE LEFT CUSHION PRESSURE AT DOWN SLEW RATE
INCREASE RIGHT CUSHION PRESSURE AT UP SLEW RATE
MAINTAIN CENTER CUSHION PRESSURE AT BASELINE
284
START LEFT (DE ROTATION
DESIRED PRESSURE REACHED
285
NO
YES
ROTATION BOOST OPTION SELECTED
286
NO
YES
DECREASE CENTER CUSHION PRESSURE
287
INCREASE CENTER CUSHION PRESSURE TO RIGHT SIDE PRESSURE
COMPLETE LEF' SIDE ROTATION
B
TO ROTATION THERAPY PAGE 2

FIG 19A

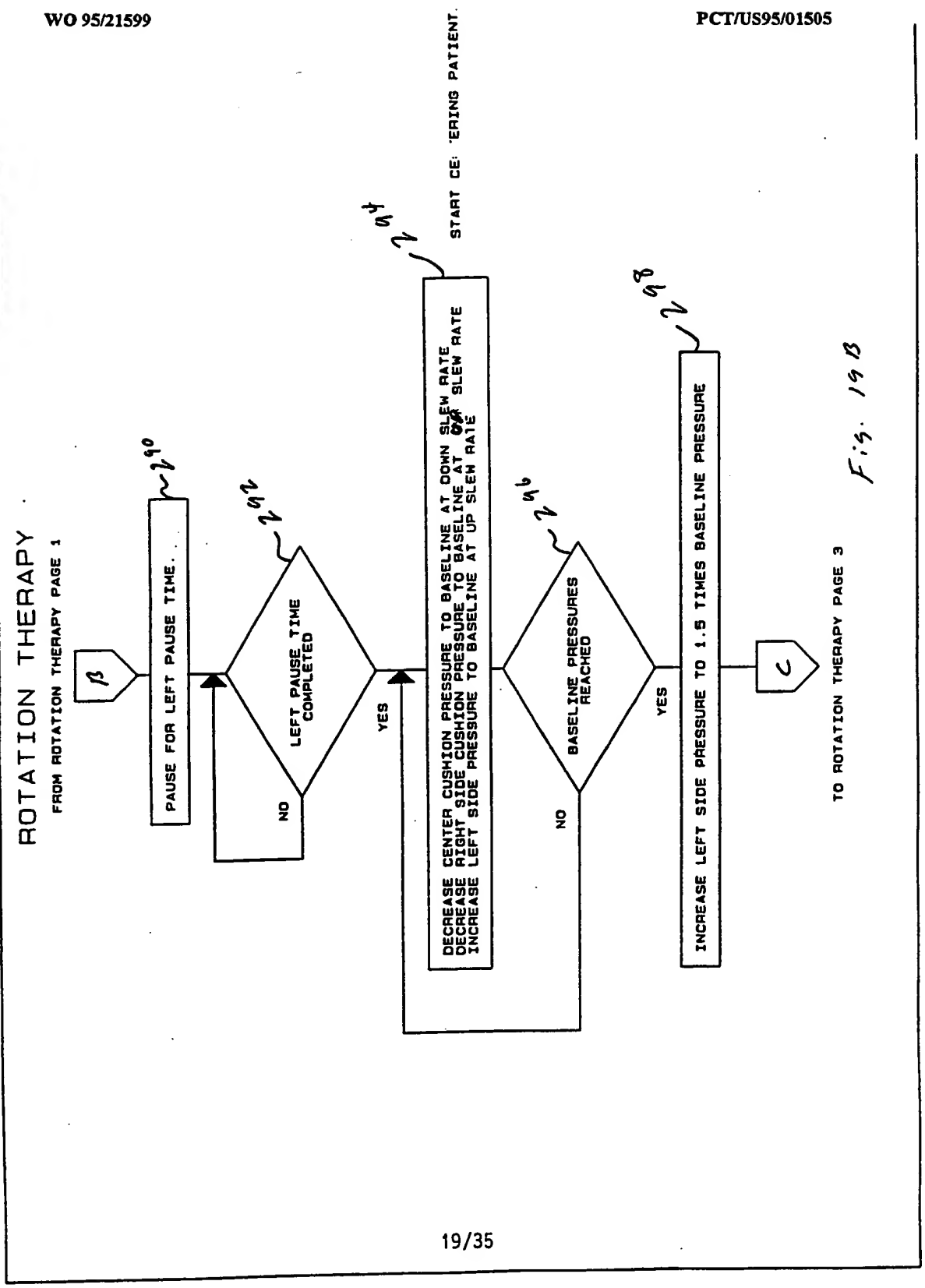

ROTATION THERAPY
FROM ROTATION THERAPY PAGE 1
B
PAUSE FOR LEFT PAUSE TIME.
190
LEFT PAUSE TIME COMPLETED
192
NO
YES
DECREASE CENTER CUSHION PRESSURE TO BASELINE AT DOWN SLEW RATE
DECREASE RIGHT SIDE CUSHION PRESSURE TO BASELINE AT OR SLEW RATE
INCREASE LEFT SIDE PRESSURE TO BASELINE AT UP SLEW RATE
194
START CE ERING PATIENT.
BASELINE PRESSURES REACHED
196
NO
YES
INCREASE LEFT SIDE PRESSURE TO 1.5 TIMES BASELINE PRESSURE
198
C
TO ROTATION THERAPY PAGE 3

Fig. 19B

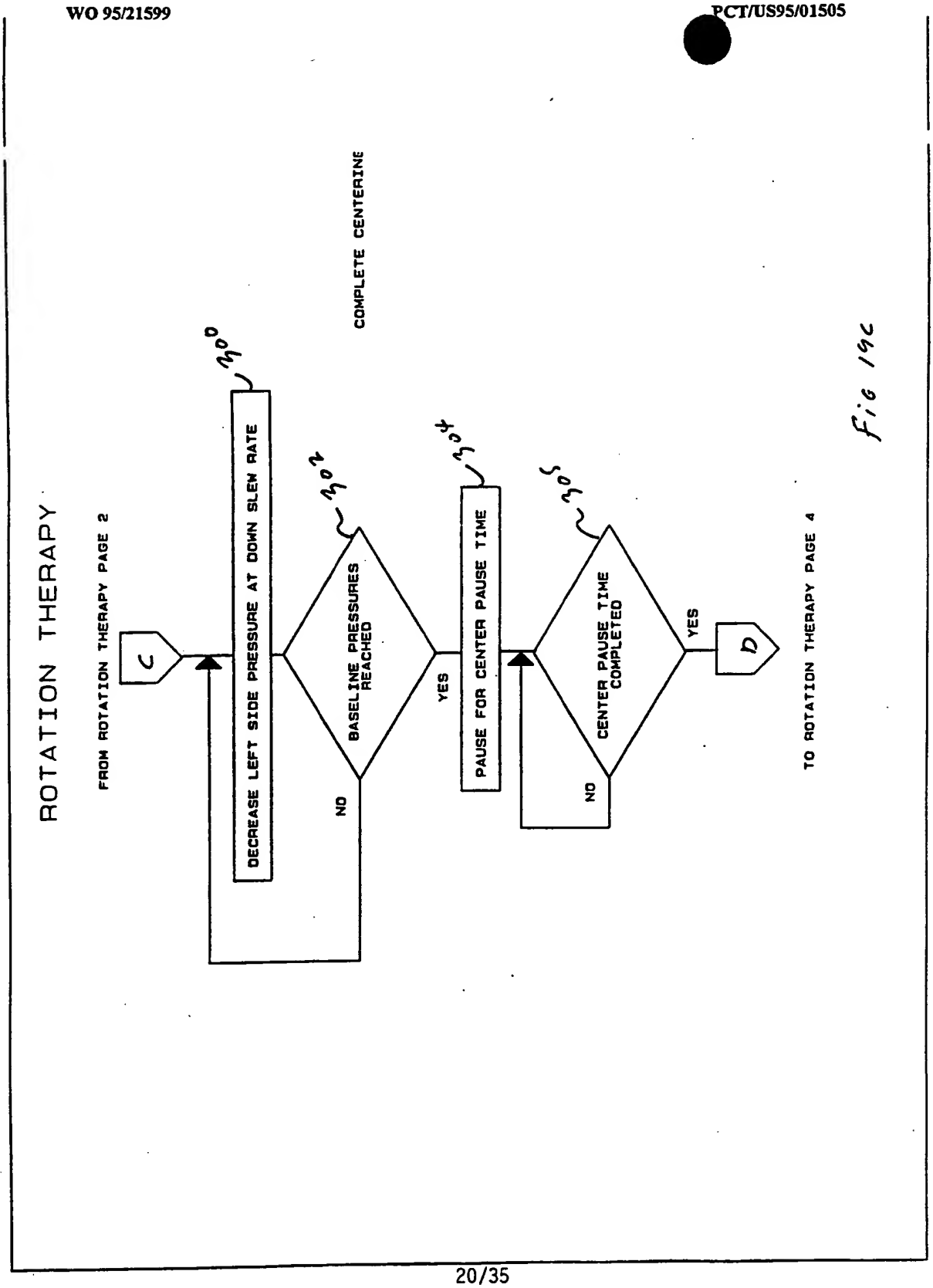

ROTATION THERAPY
FROM ROTATION THERAPY PAGE 2
C
DECREASE LEFT SIDE PRESSURE AT DOWN SLEW RATE
300
BASELINE PRESSURES REACHED
302
NO
YES
PAUSE FOR CENTER PAUSE TIME
304
CENTER PAUSE TIME COMPLETED
305
NO
YES
D
TO ROTATION THERAPY PAGE 4
COMPLETE CENTERING

Fig 19c

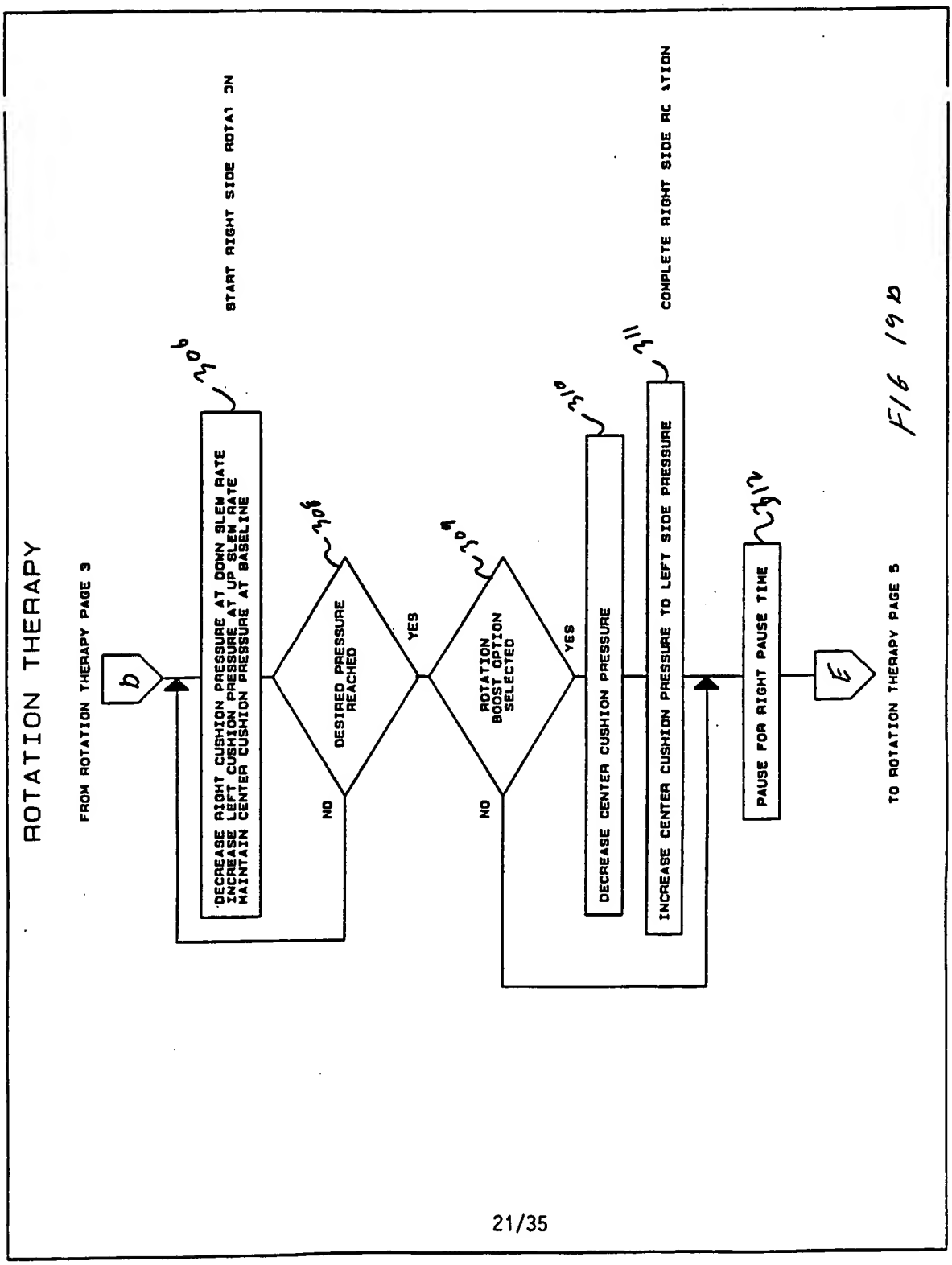

ROTATION THERAPY
FROM ROTATION THERAPY PAGE 3
b
DECREASE RIGHT CUSHION PRESSURE AT DOWN SLEW RATE
INCREASE LEFT CUSHION PRESSURE AT UP SLEW RATE
MAINTAIN CENTER CUSHION PRESSURE AT BASELINE
START RIGHT SIDE ROTATION
DESIRED PRESSURE REACHED
YES
NO
ROTATION BOOST OPTION SELECTED
YES
NO
DECREASE CENTER CUSHION PRESSURE
INCREASE CENTER CUSHION PRESSURE TO LEFT SIDE PRESSURE
COMPLETE RIGHT SIDE ROTATION
PAUSE FOR RIGHT PAUSE TIME
E
TO ROTATION THERAPY PAGE 5

FIG 19b

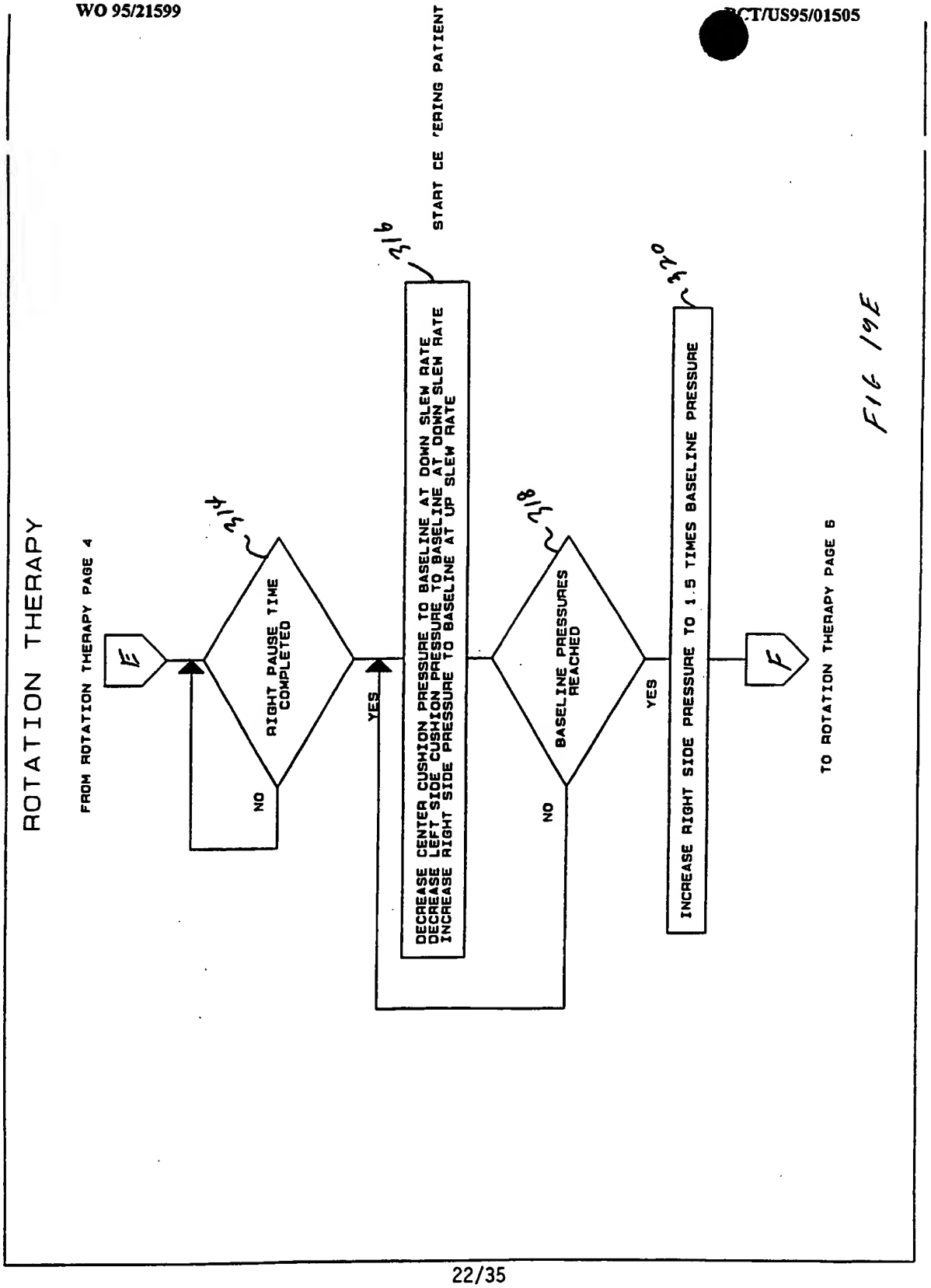

ROTATION THERAPY
FROM ROTATION THERAPY PAGE 4
E
RIGHT PAUSE TIME COMPLETED
NO
YES
DECREASE CENTER CUSHION PRESSURE TO BASELINE AT DOWN SLEW RATE
DECREASE LEFT SIDE CUSHION PRESSURE TO BASELINE AT DOWN SLEW RATE
INCREASE RIGHT SIDE PRESSURE TO BASELINE AT UP SLEW RATE
START CE 'ERING PATIENT
BASELINE PRESSURES REACHED
NO
YES
INCREASE RIGHT SIDE PRESSURE TO 1.5 TIMES BASELINE PRESSURE
F
TO ROTATION THERAPY PAGE 6
214
216
218
220

FIG 19E

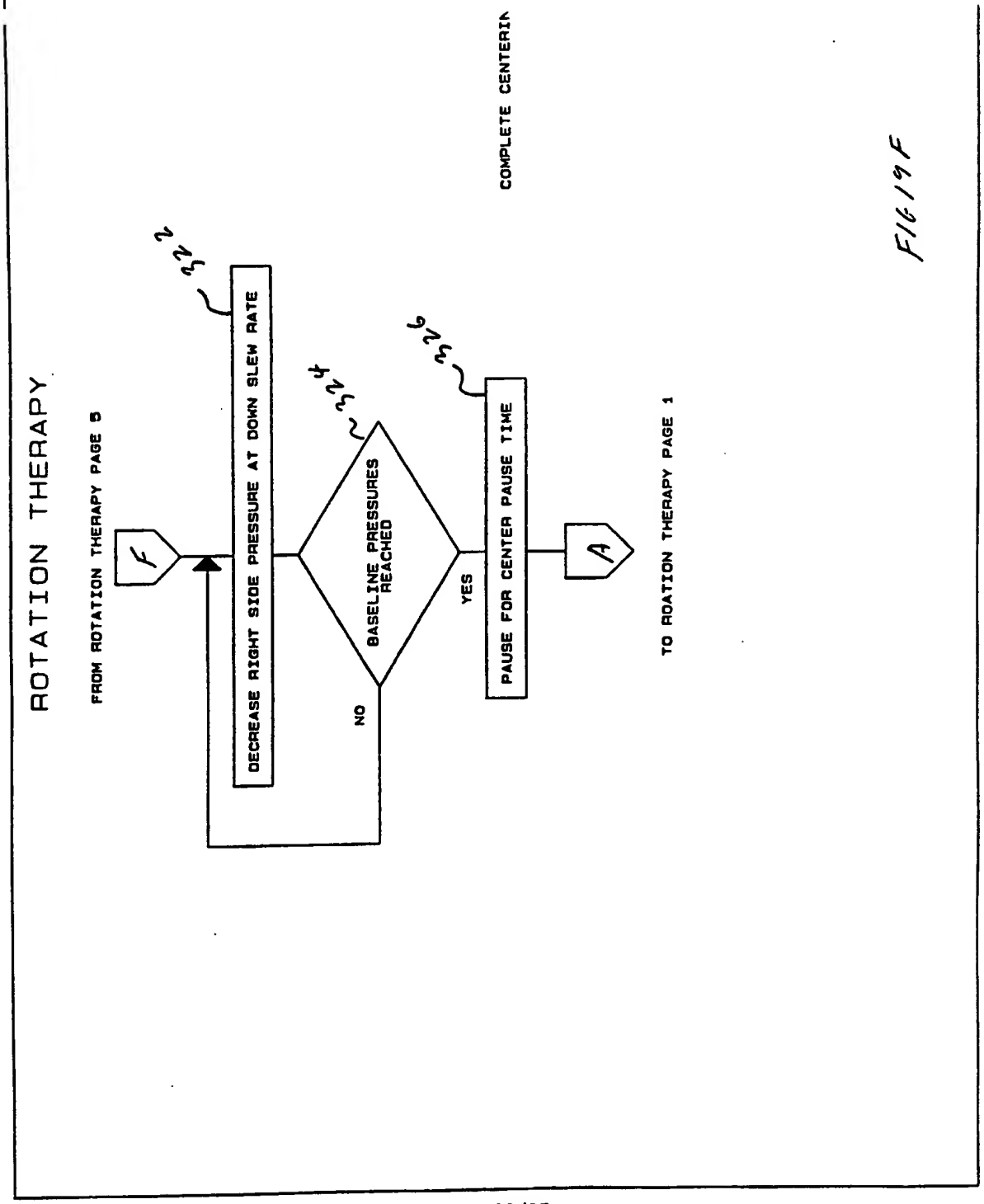

ROTATION THERAPY
FROM ROTATION THERAPY PAGE 5
F
DECREASE RIGHT SIDE PRESSURE AT DOWN SLEW RATE
BASELINE PRESSURES REACHED
NO
YES
PAUSE FOR CENTER PAUSE TIME
A
TO ROATION THERAPY PAGE 1
COMPLETE CENTERIN

FIG 19F

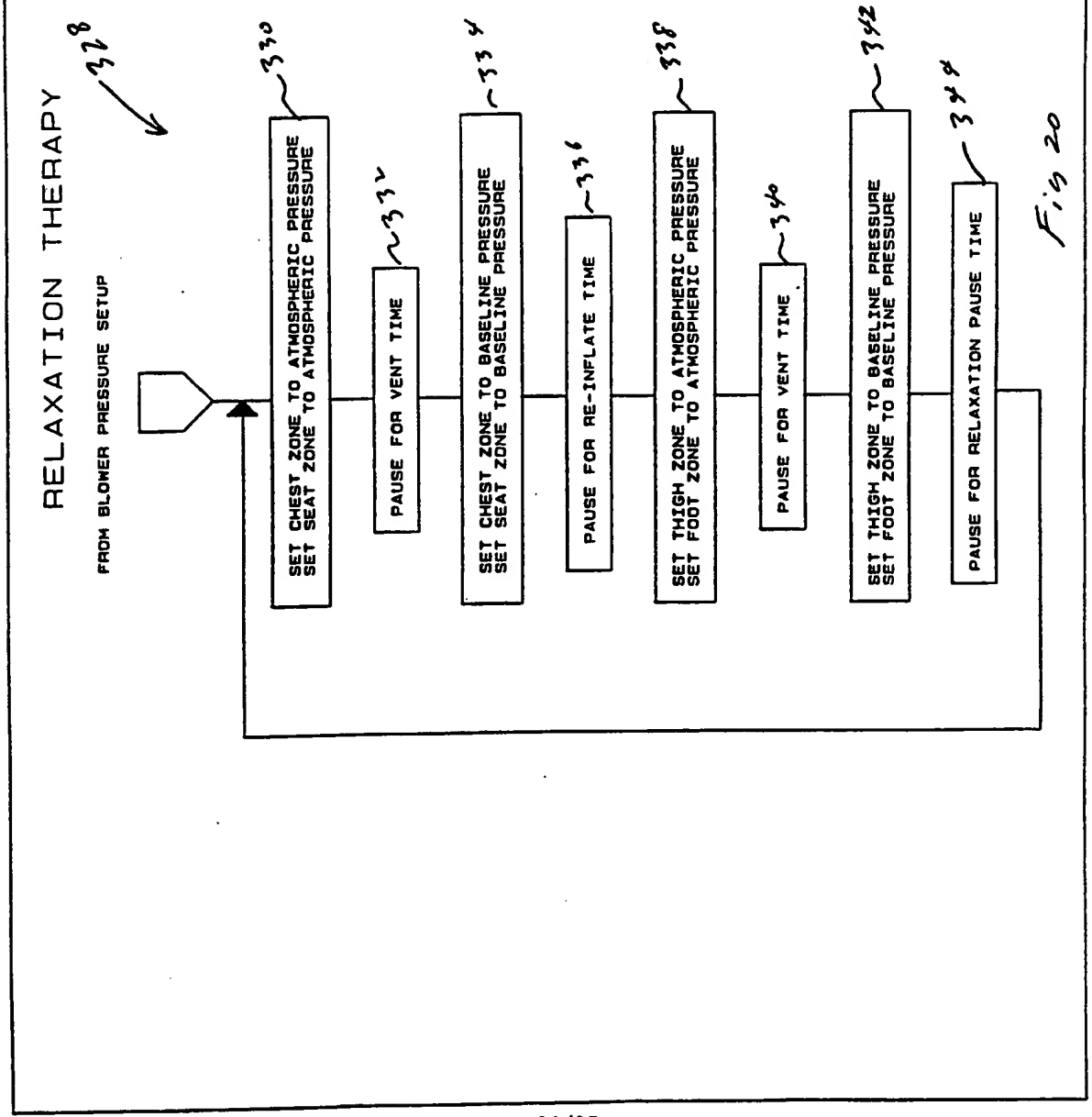

RELAXATION THERAPY
338
FROM BLOWER PRESSURE SETUP
330
SET CHEST ZONE TO ATMOSPHERIC PRESSURE
SET SEAT ZONE TO ATMOSPHERIC PRESSURE
332
PAUSE FOR VENT TIME
334
SET CHEST ZONE TO BASELINE PRESSURE
SET SEAT ZONE TO BASELINE PRESSURE
336
PAUSE FOR RE-INFLATE TIME
338
SET THIGH ZONE TO ATMOSPHERIC PRESSURE
SET FOOT ZONE TO ATMOSPHERIC PRESSURE
340
PAUSE FOR VENT TIME
342
SET THIGH ZONE TO BASELINE PRESSURE
SET FOOT ZONE TO BASELINE PRESSURE
344
PAUSE FOR RELAXATION PAUSE TIME

Fig 20

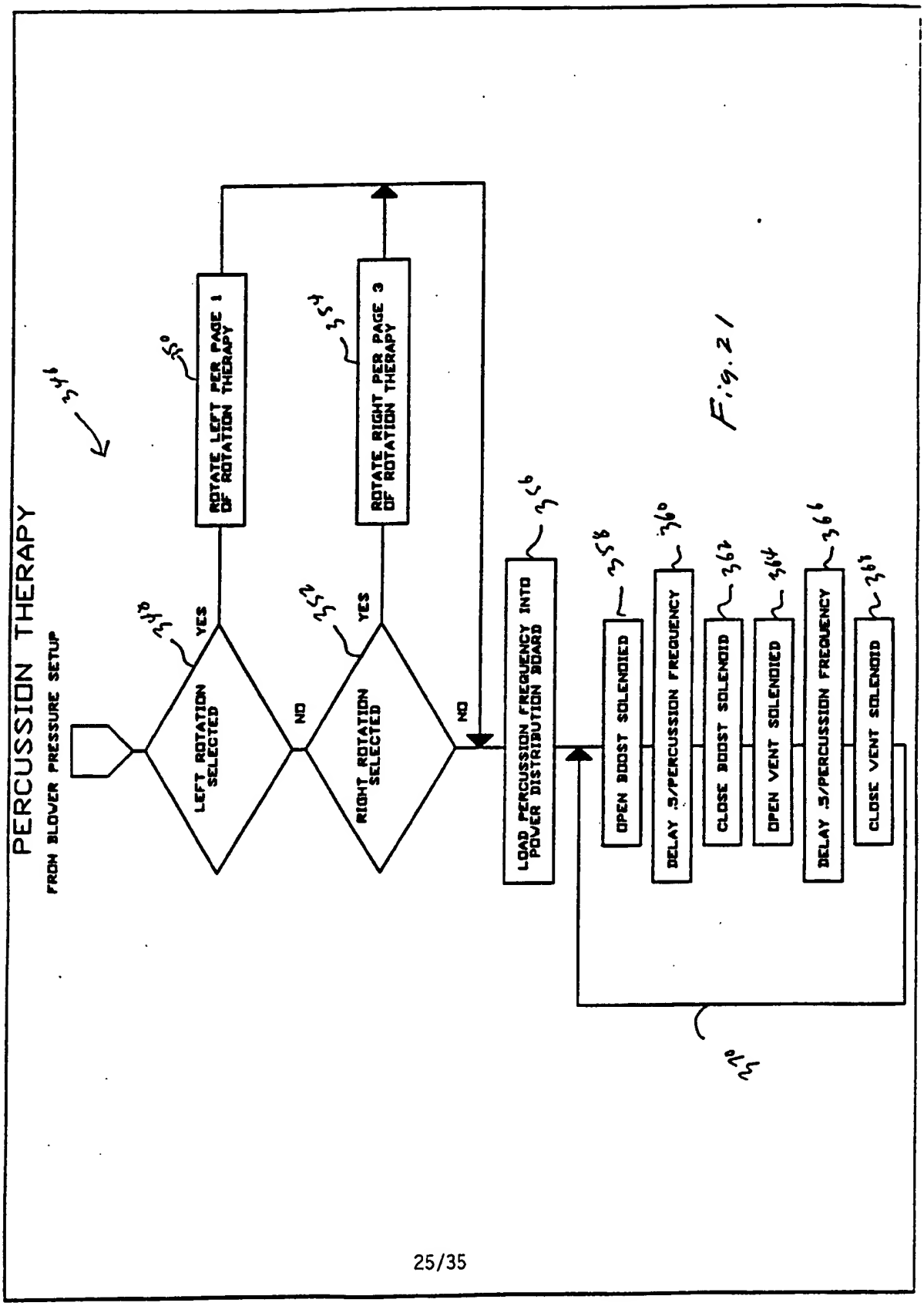

PERCUSSION THERAPY
FROM BLOWER PRESSURE SETUP
LEFT ROTATION SELECTED
YES
NO
ROTATE LEFT PER PAGE 1 OF ROTATION THERAPY
RIGHT ROTATION SELECTED
YES
NO
ROTATE RIGHT PER PAGE 3 OF ROTATION THERAPY
LOAD PERCUSSION FREQUENCY INTO POWER DISTRIBUTION BOARD
OPEN BOOST SOLENOID
DELAY .5/PERCUSSION FREQUENCY
CLOSE BOOST SOLENOID
OPEN VENT SOLENOID
DELAY .5/PERCUSSION FREQUENCY
CLOSE VENT SOLENOID

Fig. 21

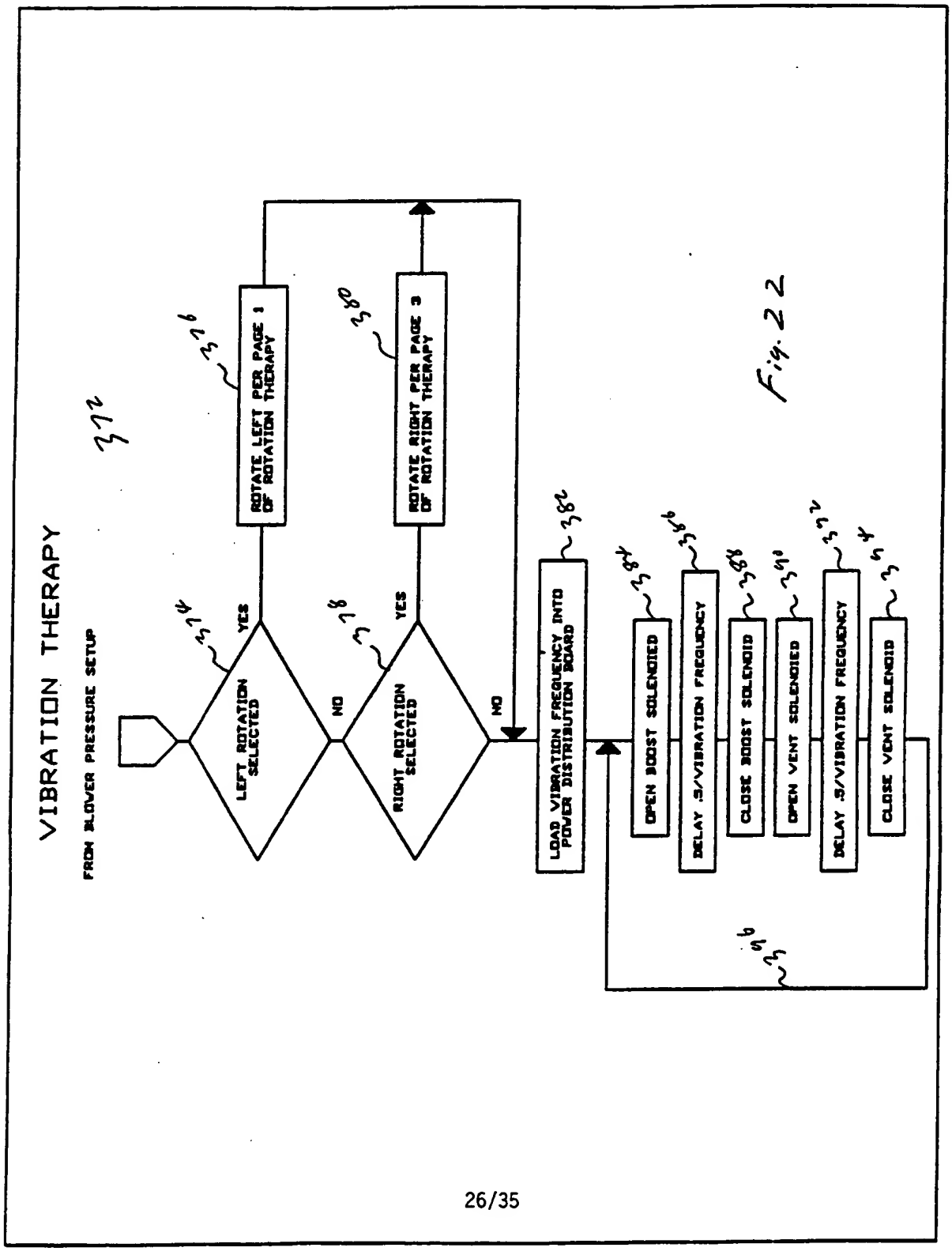

VIBRATION THERAPY
FROM BLOWER PRESSURE SETUP
372
LEFT ROTATION SELECTED
YES
NO
376
ROTATE LEFT PER PAGE 1 OF ROTATION THERAPY
RIGHT ROTATION SELECTED
YES
NO
380
ROTATE RIGHT PER PAGE 3 OF ROTATION THERAPY
382
LOAD VIBRATION FREQUENCY INTO POWER DISTRIBUTION BOARD
384
OPEN BOOST SOLENOIED
386
DELAY .5/VIBRATION FREQUENCY
388
CLOSE BOOST SOLENOID
390
OPEN VENT SOLENOIED
392
DELAY .5/VIBRATION FREQUENCY
394
CLOSE VENT SOLENOID
396

Fig. 22

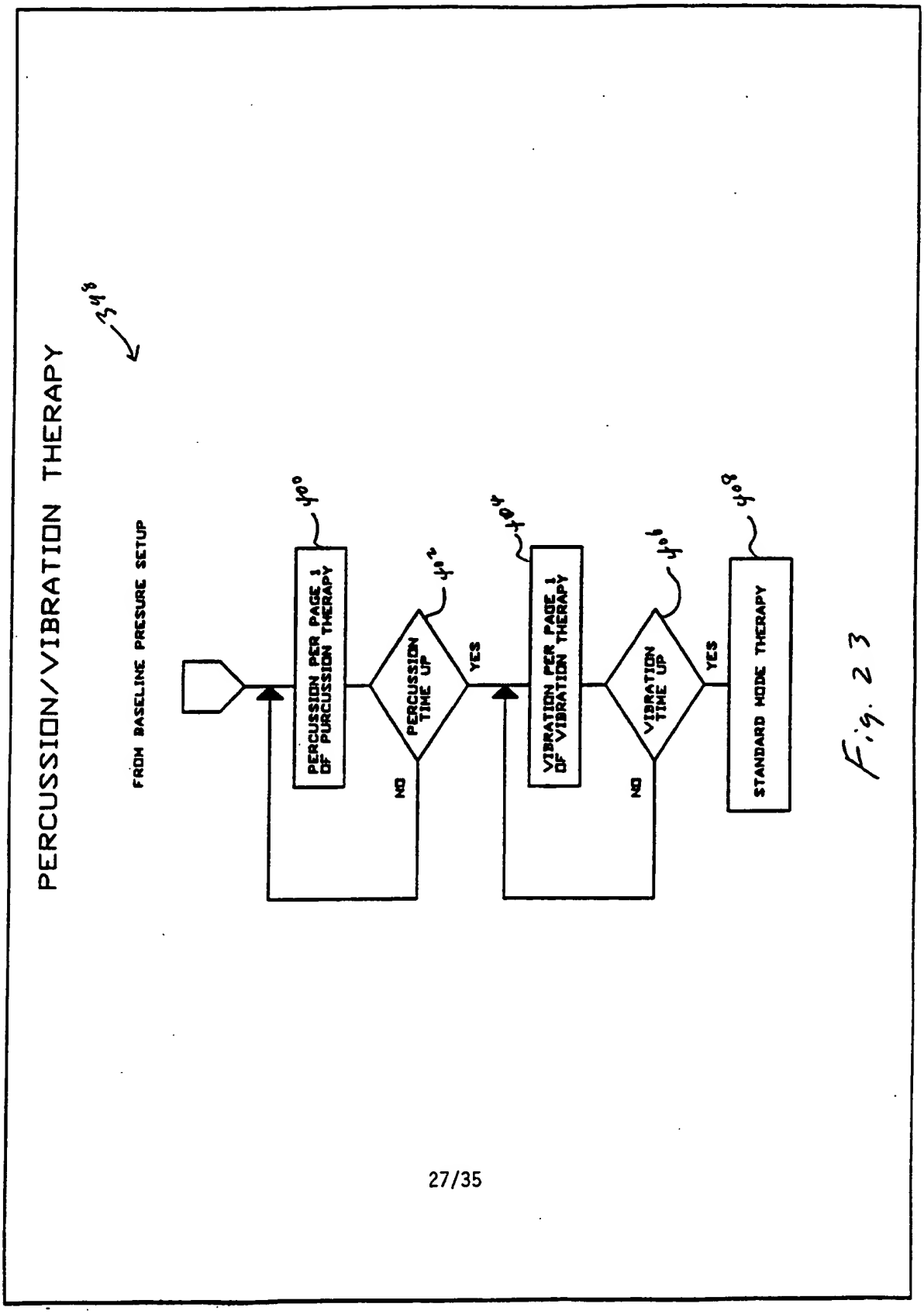

PERCUSSION/VIBRATION THERAPY
FROM BASELINE PRESURE SETUP
PERCUSSION PER PAGE 1 OF PURCUSSION THERAPY
PERCUSSION TIME UP
YES
NO
VIBRATION PER PAGE 1 OF VIBRATION THERAPY
VIBRATION TIME UP
YES
NO
STANDARD HOME THERAPY

Fig. 23

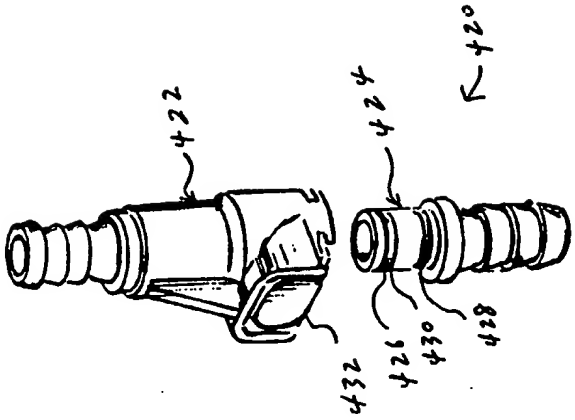


FIG. 25

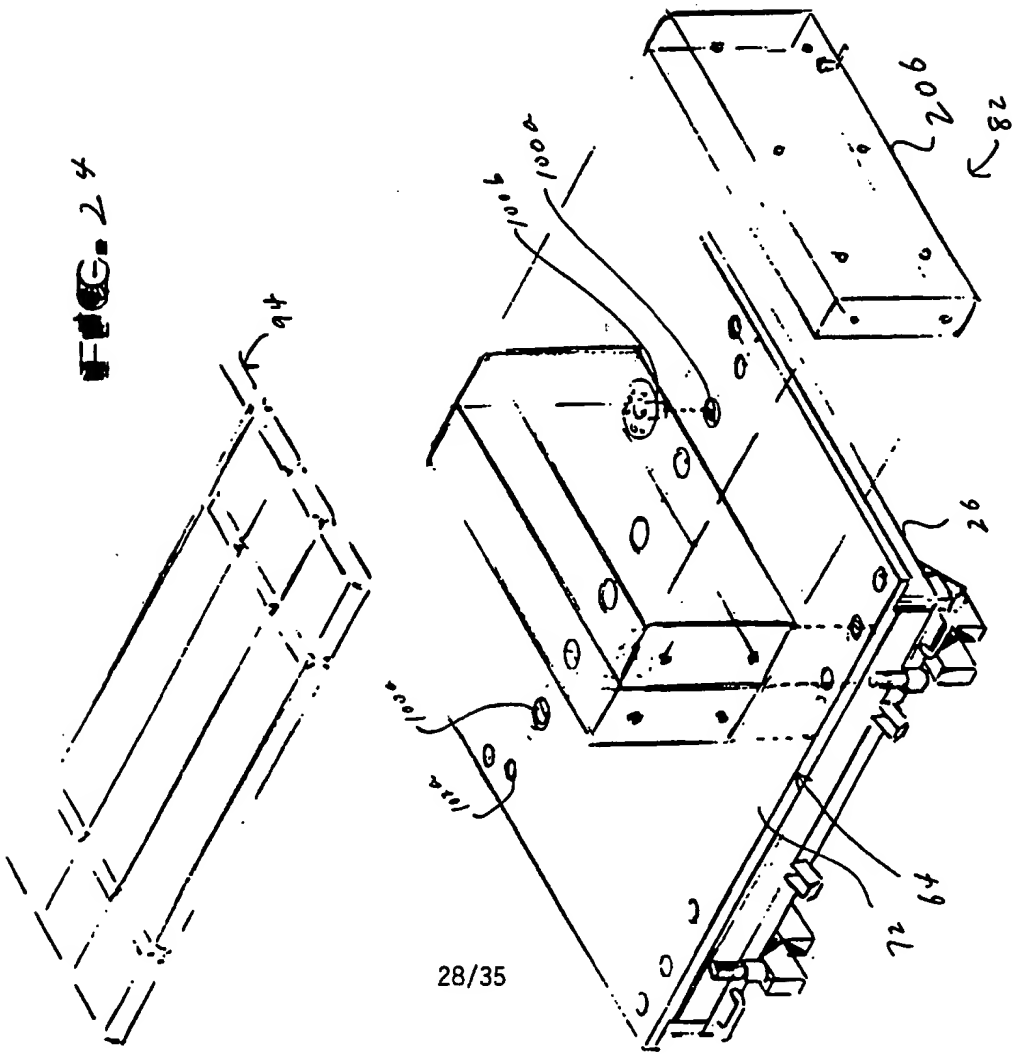


FIG. 24

Fig. 26A

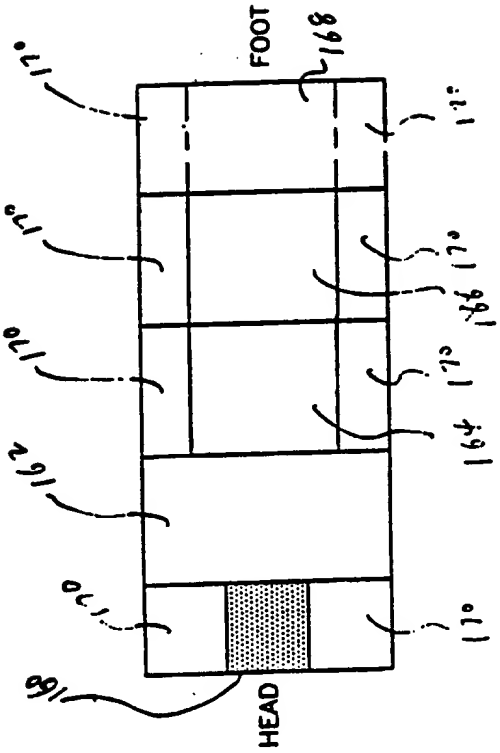
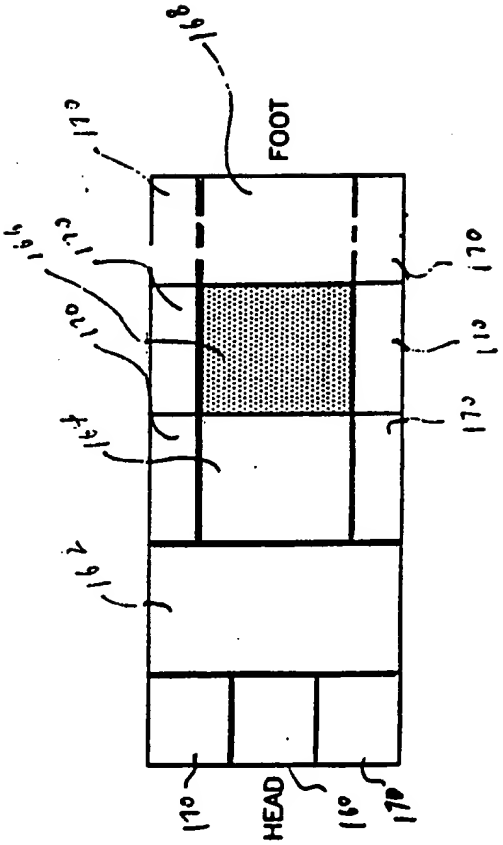
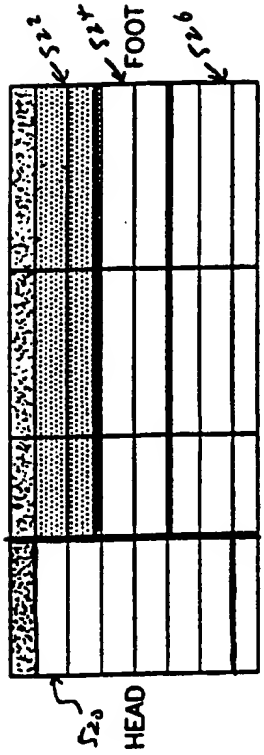


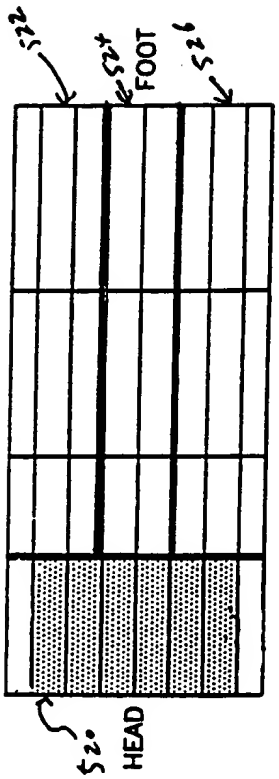
Fig. 26B



27A



27B



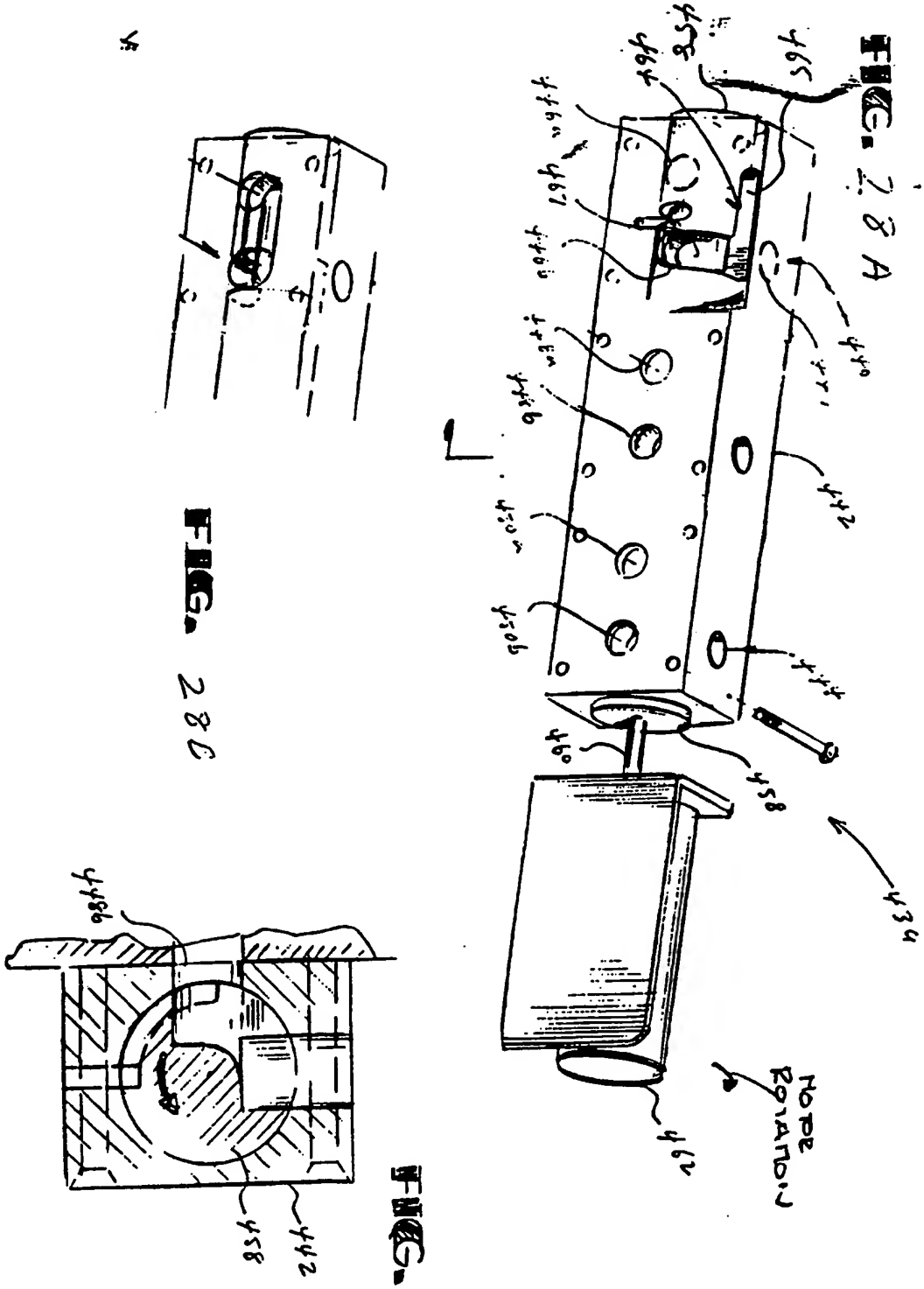


FIG. 28A

FIG. 28C

FIG. 28C

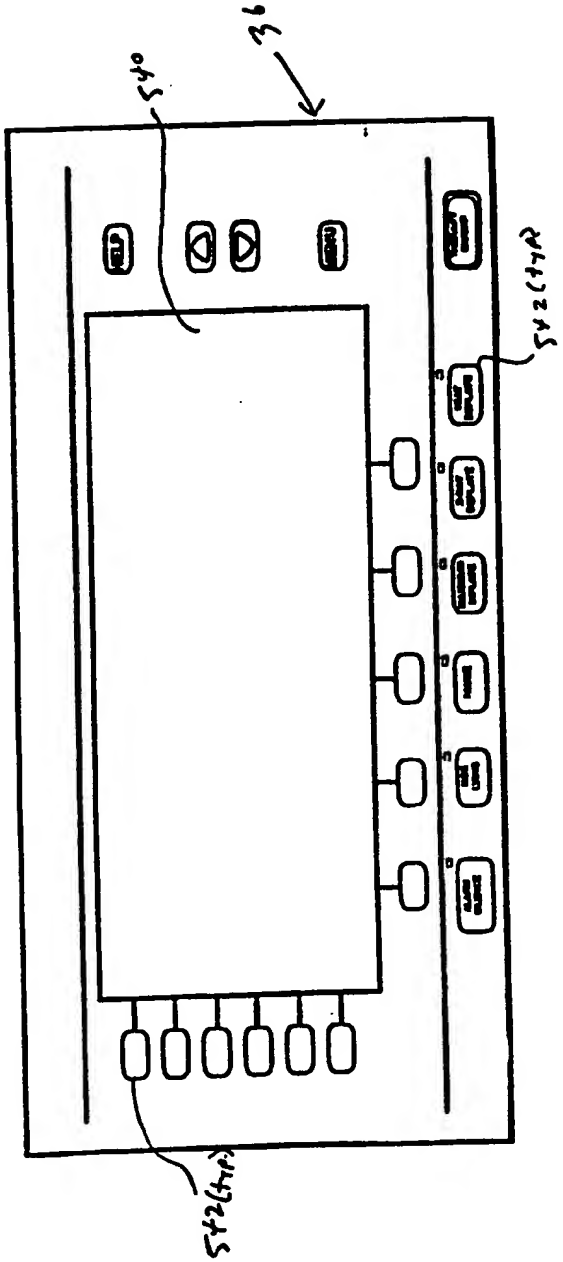


Fig. 29

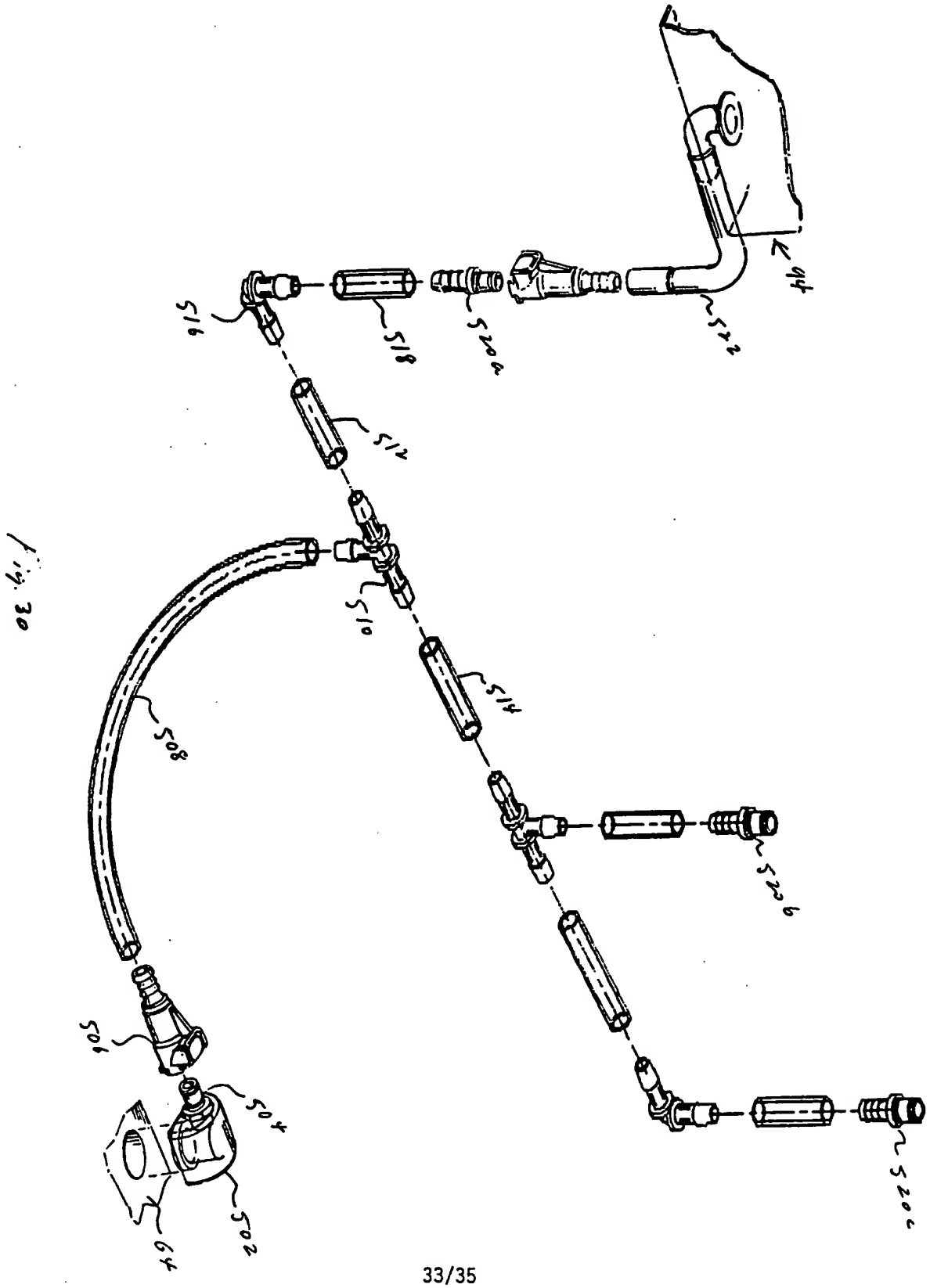


Fig. 30

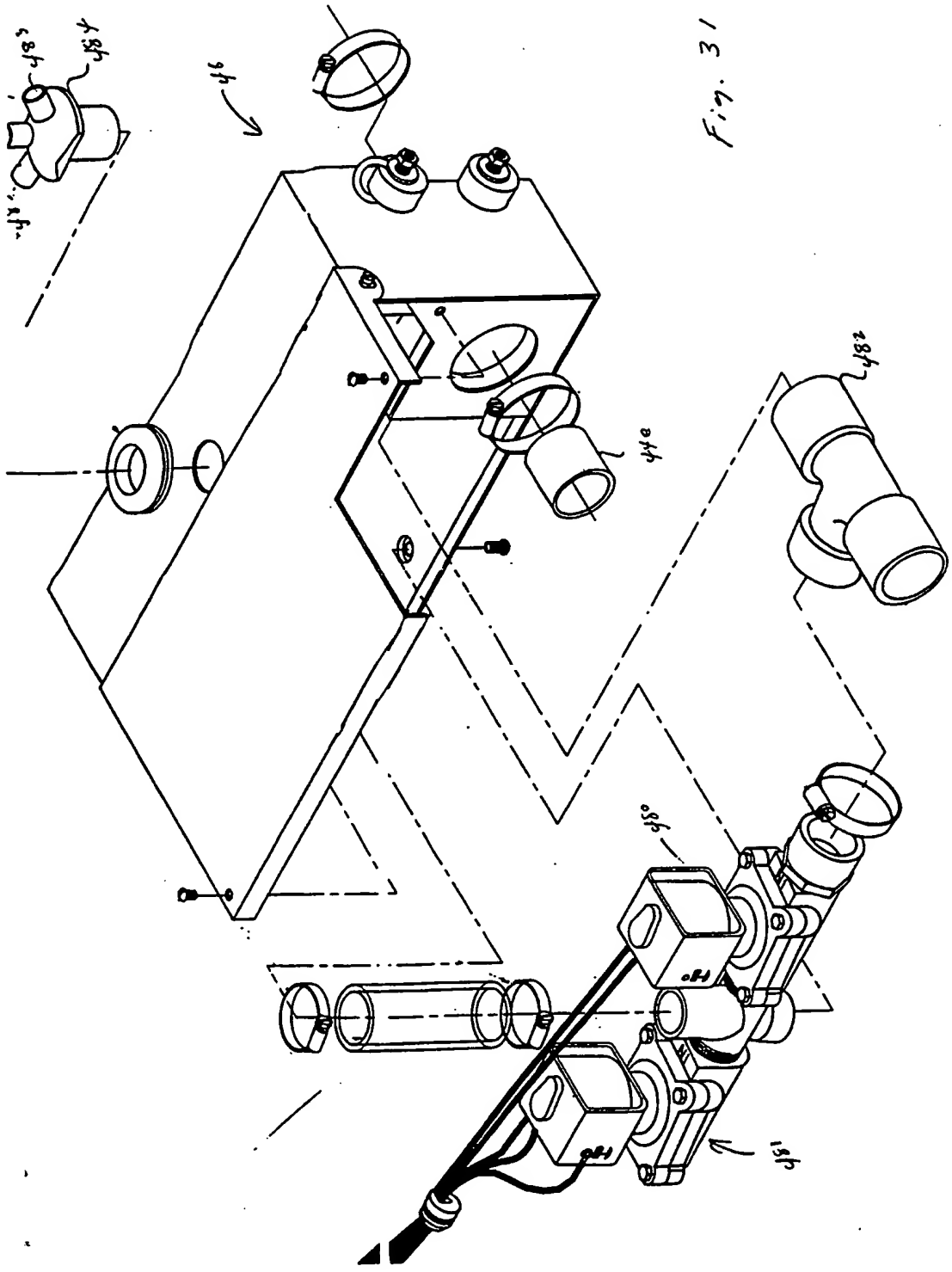


Fig. 31

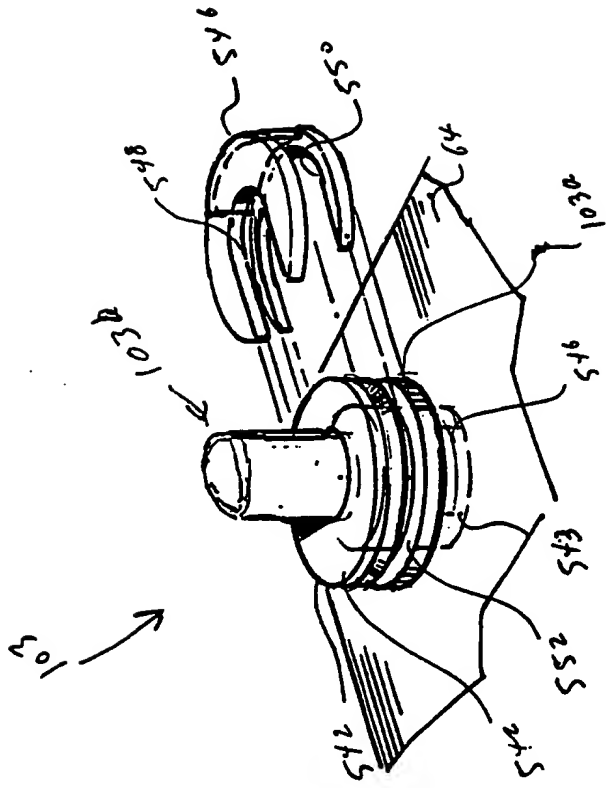


Fig. 32

INTERNATIONAL SEARCH REPORT

International application No.
PCT/[redacted]01505

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A61G 7/00
US CL :5/453

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 5/449, 453, 455, 457, 468, 469, 914

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	US, A 5,323,500 (Roe et al) 28 June 1994 Read the entire document.	17, 18, 23, 24, 41
X,P	US, A 5,373,595 (Johnson et al) 20 December 1994 Note the valve structure shown in Figure 3 in particular.	44, 45
A	US, A 5,138,729 (Ferrand) 18 August 1992 Read the entire document.	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 June 1995	05 JUL 1995
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MICHAEL TRETTEL Telephone No. (703) 308-2168

Form PCT/ISA/210 (second sheet)(July 1992)*